HMT-0031

FEBRUARY, 1980

HELENA – HELENA VALLEY WASTEWATER FACILITIES PLAN

WASTEWATER TREATMENT PLANT SLUDGE HANDLING STUDY

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Transmitted with this letter are twenty-five copies of the Wastewater Treatment Plant Sludge Handling Study. This report is a supplement to the Helena - Helena Valley Wastewater Facilities Plan, and concentrates on the solids handling problems that have occured at the Wastewater Treatment Plant.

Included in this report are: 1) a detailed analysis of the existing solids handling system including the Purifax unit, 2) an investigation into the odor problem at the Treatment Plant, 3) recommendations for an Interim Plan meeting the requirements of the Compliance Order issued by the State Department of Health, 4) recommendations for permanent improvements to the solids handling process for the planning period, and 5) costs to implement the recommendations.

Our approach to this project has been to objectively perform evaluations and scientifically substantiate recommendations to the extent that it was possible to do so. It should be recognized, however, that certain investigations are beyond present technological capabilities, and precise answers are not obtainable within reasonable time and budget constraints. This is particularly the case with the odor problem and suspected harmful compounds that may be created in the chlorinated sludge.

We believe our analysis to be thorough and our recommendations sound with the limitation that they are based on currently available information. As new information surfaces or regulations change, modifications to this study may be required. We have attempted to retain as much flexibility as possible in our recommendations while still maintaining a clear course of action for the City to follow.

As a final note, it should be clarified that we know of no wastewater treatment process that is completely odor-free or foolproof. Our recommendations include processes that have been technologically proven as sound and reliable, but even these processes will likely have instances of malfunction.

This has been one of our most interesting and challenging projects, and we appreciate the opportunity to provide this service to Helena and Lewis and Clark County.

Yours very truly,

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HELENA – HELENA VALLEY WASTEWATER FACILITIES PLAN

WASTEWATER TREATMENT PLANT SLUDGE HANDLING STUDY

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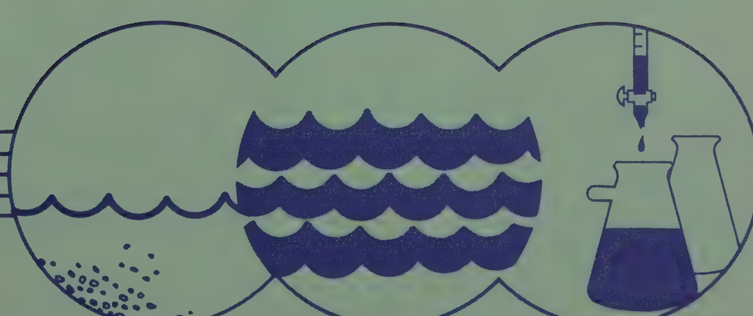


CHAPTER I
INTRODUCTION

This sludge handling study has been prepared as a supplement to the 1978 Helena - Helena Valley Wastewater Facilities Plan to provide a detailed evaluation of solids handling practices at the Helena Wastewater Treatment Plant. The original Wastewater Facilities Plan contained a comprehensive investigation of wastewater management options for the Helena municipality as well as the Helena Valley area. A broad-based approach was emploloyed considering wastewater generation, collection, treatment and ultimate disposal. Sludge handling was addressed as a part of the original plan, and the existing system as well as various alternatives were investigated. This specialized study focuses on that particular aspect of Helena's wastewater treatment and disposal activities and addresses the existing system and the most viable alternative in depth.

Alternative sludge handling technologies presented in the original Wastewater Facilities Plan have been reviewed and supplemented as warranted. A significant part of this sludge handling study involved a rigorous analytical testing program oriented toward performance monitoring of the existing sludge handling facility. Data thus generated found application in the evaluation of all alternatives under consideration. The final result of this study is a recommended plan for future sludge handling activity in the Helena - Helena Valley area.

A. BACKGROUND — ORIGINAL WASTEWATER FACILITIES PLAN

The Wastewater Facilities Plan for Helena - Helena Valley, Montana was prepared jointly in 1978 by Black & Veatch of Kansas City, Missouri and Daily-Peccia & Associates of Helena in partial fulfillment of the Construction Grants Program Requirements of the U.S. Environmental Protection Agency (EPA). Thereafter the plan was adopted by the Areawide Planning Organization, Lewis and Clark County and the City of Helena and submitted to the EPA for approval. Grant Amendment Number 1 was approved in 1979 to afford an additional wastewater treatment plant sludge disposal study to which this text is addressed. EPA approval of the original Wastewater Facilities Plan is being withheld pending submission of this amendment study.

B. SCOPE OF STUDY

This sludge handling study serves to address wastewater solids treatment and disposal practices at the Helena Wastewater Treatment Plant situated along Custer Avenue directly east of Interstate I-15. It is the intent of this document to provide a practical planning tool for sludge management during the designated planning period based on the investigation and analyses summarized herein.

This study was conducted in accordance with the following primary objectives:

1. Review available information on sludge produced and soil characteristics in the area of the treatment plant.
2. Initiate a program of sampling and testing to determine further characteristics of sludge produced and of soil at potential disposal sites.
3. Consult with appropriate local, state and federal agencies concerning the selection and design requirements of a sludge disposal site.
4. Review sample test results, evaluate available alternatives and recommend a method of sludge disposal for the City.

Various alternative sludge handling plans have been developed and screened for economic viability and environmental soundness. A rigorous analytical testing program related to the existing solids handling system was employed to lend precision to this screening process. The most attractive alternative has been cited and further developed, and serves as a basis for the final recommendations of this study.

C. PLANNING AREA

The planning area encompassed for this sludge handlng study is identical to that presented in the original Helena - Helena Valley Wastewater Facilities Plan (1978), which includes the municipality of Helena and the adjoining Helena Valley. By nature of the study subject, the focus of this report will be essentially restricted to the facilities at the Helena Wastewater Treatment Plant where municipal wastewater solids are presently collected, treated and disposed. Current practices also utilize some adjacent open lands for land disposal of sludge. The minor volume of wastewater solids associated with private treatment and disposal systems within the study area are not considered in this study.

D. PLANNING TIME PERIOD

This study has been undertaken with the intent of providing a plan for sound wastewater sludge handlng and disposal for the study area through the year 2000. It has been recognized and documented in the original Wastewater Facilities Plan that existing facilities will not be adequate in themselves for wastewater solids generated in that period.

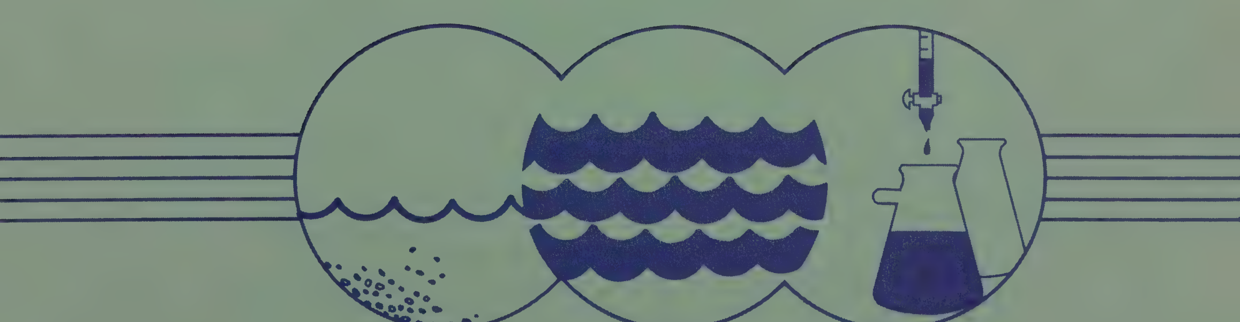
E. JURISDICTIONAL AND ADMINISTRATIVE RESPONSIBILITIES

The Helena Wastewater Treatment Plant and solids handling equipment associated with it are owned and operated by the City of Helena. Individuals presently executing this responsibility include employees of the Department of Public Utilities, the Director of Public Utilities, the City Manager and

the City Commissioners. Regulatory responsibility for plant operations compliance with all applic-able state and federal discharge regulations is executed by the Water Quality Bureau of the Montana Department of Health and Environmental Sciences (MDHES) acting in conjunction with the U.S. Environmental Protection Agency. Plant discharges are governed by MDHES permit, "Authorization to Discharge Under the Montana Pollutant Discharge Elimination System". This sludge handling study, in combination with the original Wastewater Facilities Plan for the area, is submitted as a qualifying step in the EPA Construction Grants Program. Procural of the necessary local capital to implement any suggested improvements to existing treatment facilities will likely involve an adjustment of municipal sewer rates contingent on approval by the Public Services Commission. EPA fiscal participation in such improvements typically can occur at either a 75 or 85 percent level, the latter being associated with particularly unique designs that qualify as Innovative and Alternative.

CHAPTER II

Assessment of Existing Situation



CHAPTER II

ASSESSMENT OF EXISTING SITUATION

Management of municipal wastewater solids in the Helena area has been the center of heated public controversy during the past year. Legal recourses have been invoked on occasion, and significant media coverage has been devoted to the issues. The controversy has centered around the creation and dispersion of offensive odors in the Helena - Helena Valley area, and speculations have been raised regarding adverse environmental impacts associated with the existing sludge handling system.

A. SUMMARY OF ORIGINAL ENVIRONMENTAL ASSESSMENT

The study area occupies a broad intermountain valley overlain by relatively uniform alluvial deposits, and bordered to the east by the Missouri River. Restrictions are posed to the use of significant portions of the soils in the area due to seasonally high water tables, shallow bedrock or restricted permeabilities. These considerations are particularly critical to prospective sitings of landfills, drainfields, etc. Surface water resources in or near the study area include Lake Helena, Silver Creek, Prickly Pear Creek, Tenmile Creek and the Missouri River, some of which contribute to the Helena municipal water supply. Agricultural irrigation is typical in the outlying valley area; the Helena Valley Regulating Reservoir supplied by water from the Missouri River and an extensive peripheral canal system make this possible. A heterogenous basin-fill aquifer underlies most of the valley area at moderate depths, and good quality groundwater circulates fairly readily therein.

Air quality within the study area is generally good, although infrequent violations of applicable federal and state standards for particulates and sulfur dioxide emissions have been recorded. The air quality consideration paramount to this study involves the release of noxious odors associated with the treatment and disposal of municipal wastewater sludge. The issue of creation of a public nuisance has been periodically raised in this regard and has been the basis for recent litigation.

Life forms indigenous to the study area are diverse, as is suggested by the abundant and varying habitat available including waterways, lowlands, grasslands, foothills and mountains. Enumerations of the various species of flora and fauna present are contained in the Environmental Assessment of the original Facilities Plan.

Within the study area the Helena municipality occupies the southcentral portion with the usual civil land uses predominating. Elsewhere in the area open space with alternating irrigated cropland and pasture lands is typical, interspersed with frequent low-density development. Community facilities and services and socio-economic characteristics are reflective of the size and location of the Helena community and the presence of the state capital and associated state government offices.

Cultural resources for the area include limited archeological sites and a colorful background typical of its Indian history and later gold boom days.

B. EXISTING WASTEWATER TREATMENT SYSTEM (LIQUID STREAM)

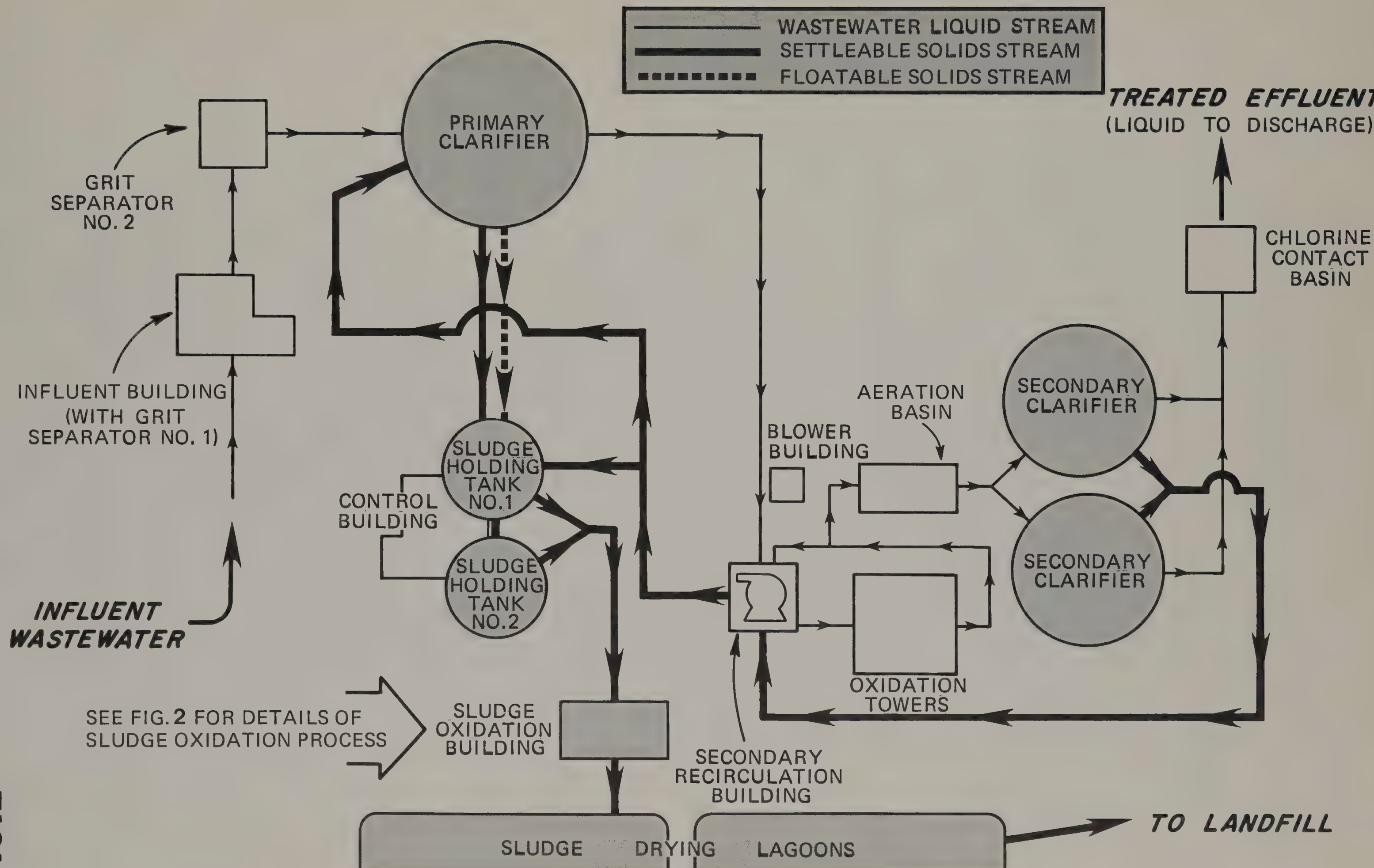
The existing central wastewater treatment facility for the City of Helena is located in the northeast corner of the City at the intersection of Washington Street and Custer Avenue. The treatment plant includes both primary and secondary treatment facilities that have been constructed in several stages. The original primary treatment plant was constructed in 1960. Several changes were made to the primary treatment plant, and secondary treatment facilities were added in 1974. In January 1978, a short-term aeration basin was completed and put into operation as part of the secondary treatment process in an effort to improve effluent quality during cold weather operations. Construction during 1979 provided additional sludge lagoons and added ventilation to the existing headworks buildings. A schematic of the existing treatment process is shown on Figure 1, and Table 1 lists size and capacities of the various unit processes.

1. Preliminary Treatment

Raw wastewater enters the plant through a 42-inch gravity sewer line at the Influent Building. The Influent Building contains a grit separator (No. 1), two parallel comminutors, and a 24-inch Parshall metering flume. Grit Separator No. 1 is of the constant-level, short-term sedimentation type with a circular collector mechanism. Grit settles to the bottom of the basin and is collected in peripheral depressions in the basin and pumped to a cyclone separator. The cyclone separator washes the collected grit and returns organics to the plant flow. The unit can be bypassed through a 24-inch pipe when maintenance is required.

Flow passes from the grit separator through two manually cleaned bar screens (two-inch and one-inch openings, respectively) or a comminutor. This unit shreds and grinds any fibrous or stringy material in the flow; the material is reduced in size until it will pass through 3/8-inch slots in the machine and remains in the flow, which then goes to the Parshall flume. Flow passing through the flume is indicated, recorded and totalized on the main control panel in the Control Building.

Effluent from the Parshall flume normally flows to Grit Separator No. 2 and the primary clarifier. An overflow weir at the discharge end of the flume allows flows in excess of 10-11 mgd to bypass directly to the secondary treatment portion of the plant. Recent improvements in the collection system have substantially reduced the peak flow rates entering the plant; thus bypassing of flow peaks should occur only in extreme situations.



SOLIDS GENERATION IN HELENA WASTEWATER TREATMENT PROCESS (schematic)

FIGURE 1

TABLE 1
EXISTING TREATMENT UNITS

UNIT	DESIGN
Average Daily Flow (Q_{avg})	6.0 mgd
Max. Daily Flow (Q_{max})	12.0 mgd
Grit Separator No. 1	1 unit
Size	20′ x 20′ x 3′ SWD
Velocity @ Q_{avg}	0.15 fps
Comminutor	2 units
Parshall Flume	24-inch throat
Capacity (limited by meter)	14.0 mgd
Grit Separator No. 2	1 unit
Size	20′ dia. x 5′ SWD
Velocity @ Q_{avg}	0.1 fps
Primary Clarifier	1 unit
Size	85′ dia. x 11′ SWD
Surface Overflow Rate @ Q_{avg}	1060 gpd/sf
Detention Time @ Q_{avg}	1.9 hrs.
Vee-notched weir length	265 lf
Weir overflow rate @ Q_{avg}	940 gpd/lf
Sludge Collector	Radial, blade-type
Sludge Removal Pumps	2 @ 46-140 gpm ea. (Moyno)
Secondary Recirculation Building	
Recirculation Pumps	2 @ 7500 gpm* 1 @ 4200 gpm 1 @ 3300 gpm
Waste Sludge Pumps	2 @ 300 gpm
Biological Towers	2 units
Size (ea.)	24′ x 64′ x 14′ media depth
Hydraulic Loading Avg. @ 2.5 Recirc.	3.4 gpm/sf
Biological Loading	230 lbs. BOD_5/1000 cf
Aeration Basins	1 unit
Size	61′ 8″ x 40′ x 15′ SWD
Detention Time @ Q_{avg}	1.1 hrs.
Static Aerators	72 units
Firm Blower Capacity	2500 scfm

* One unit has both electric motor and natural gas engine drive.

TABLE 1
EXISTING TREATMENT UNITS
(CONT.)

UNIT	DESIGN
Final Clarifiers	2 units
Size	75′ dia. x 10′ 6″ SWD
Surface Overflow Rate @ Q_{avg}	680 gpd/sf
Detention Time @ Q_{avg}	2.8 hrs.
Vee-notched weir length (ea.)	235 lf
Weir overflow rate @ Q_{avg}	12,800 gpd/lf
Sludge Collector	Vacuum withdrawal
Sludge Removal	Gravity flow (14″ dia. pipe)
Chlorine Contact Basin	1 unit
Size	56′ x 68′ 3″ x 6′ 6″ SWD
Capacity	186,000 gal.
Detention Time @ Q_{max}	22 minutes
Sludge Holding Tanks	2 units
Size	45′ dia. x 20′ (approx.) SWD
Capacity	275,000 gal. ea.
Sludge Oxidation Equipment	
Chlorinator	1 unit
Chlorinator Capacity	4000 lb./day
Purifax Oxidizer	1 unit
Purifax Throughput Capacity	108 gpm
Purifax Recirculation Pump Capacity	770 gpm
Sludge Lagoons	10 cells
Total Lagoon Surface Area	11.4 acres
Available Lagoon Freeboard	8′ (approx.)

Grit Separator No. 2 is a tangential flow unit with a circular collector mechanism, and can also be bypassed when required. Grit is removed from the unit with a screw conveyor. Grit collected by the two separators is hauled daily by truck to the landfill for disposal.

2. Primary Treatment

Flow from Grit Separator No. 2 goes to the primary clarifier. Suspended solids and organics settle in the circular basin and are removed as sludge from a hopper in the bottom of the tank. Floating solids are skimmed to a collection beach and are then discharged to a scum pit. The primary sludge and scum are periodically removed from the clarifier by pumps in the Control Building to sludge storage tanks for further processing.

3. Secondary Treatment

Primary effluent flows by gravity to the Secondary Recirculation Building where secondary treatment begins. Secondary treatment removes soluble organics and suspended solids using a biological treatment process. This process combines fixed media biological towers (Activated Bio-Filter — ABF), a short-term aeration basin, final clarifiers, and sludge pumping and recirculation facilities.

The primary effluent is combined with recycle flows from the towers and return sludge from the final clarifiers in the Secondary Recirculation Pumping Station. This mixture, called mixed liquor, is pumped at a constant rate over the ABF towers.

The biological towers consist of a fixed nozzle flow distribution system and racks of horizontal redwood lath. Flow cascades over the redwood lath which supports fixed-film biological growth and aerates the mixed liquor. Effluent from the towers is split with a part discharged to the aeration basin and the remainder returned to the Secondary Recirculation Pumping Station. The percentage of flow split is treatment-dependent; that is, it is varied by operating personnel to maximize efficiency of the treatment process.

The aeration basin consists of six square interconnected cells through which mixed liquor flows in series. Each cell contains twelve static aerators which provide mixing and oxygen transfer. Air is supplied to the static aerators by three rotary positive displacement blowers housed in the Blower Building.

Effluent from the aeration basin is split equally between two final clarifiers. The circular final clarifiers are equipped with vacuum uptake sludge removal mechanisms. Return sludge flows by gravity to the Secondary Recirculation Pumping Station. Waste sludge is removed from a hopper in the bottom of the clarifiers or from the return sludge pipelines. Waste sludge can either be pumped to the

sludge storage tanks for subsequent processing or combined in the primary clarifier with the primary sludge.

4. Disinfection

Final clarifier effluent flows to the chlorine contact basin where disinfection occurs. Chlorine gas is mixed with water at the Chlorine Building to produce a chlorine solution. This solution is then injected into the wastewater at the head of the chlorine contact basin. The maze-like configuration of the basin provides adequate contact time for disinfection prior to discharge. The chlorine contact basin effluent passes over a Cipolletti weir which indicates effluent flow, and is carried by a 36-inch outfall pipe and an irrigation ditch to Prickly Pear Creek.

C. EXISTING WASTEWATER TREATMENT SYSTEM (SOLIDS HANDLING)

1. Description of Existing System

Solids are separated from the liquid wastewater stream at two separate points in the existing treatment system and combined for subsequent treatment. The overall process is shown in schematic in Figure 1. Sludge and scum are removed from the primary clarifier for interim storage prior to processing. Secondary sludge is pumped to storage from the two final clarifiers. Hydraulic and organic loads generated by the primary and secondary sludge streams are discussed in detail in the following section (p. 11).

Solids generated in the preliminary treatment processes are of the rag, grit, and heavy sediment types, and are excluded from the in-house sludge processing stream. Collected grit is removed on an as-required basis by truck transport for landfill disposal. Grit from the No. 1 Separator is washed in a cyclone separator such that the residual is relatively free of organic solids, and when combined with grit from the No. 2 unit, the resulting product is essentially inert and well suited to landfilling. Grit disposal is accomplished at a special landfill site immediately west of the existing sludge dewatering lagoons.

Primary wastewater treatment is accomplished utilizing an 85-foot diameter upflow clarifier with a vee-notched peripheral weir operated at a detention time of approximately two hours (Plate 1). Hydraulic loadings (gallons per day per square foot of surface area) on this unit are currently near maximum design standards. Detention time in the basin is adequate; however as cited in the original Facilities Plan, an additional primary clarifier is needed to insure proper performance and backup capability. Quiescence provided within this unit allows solids in the wastewater stream to settle to the bottom where they are collected and concentrated into a central hopper. Transfer of this primary sludge to temporary storage is accomplished with two progressive cavity pumps capable of 46 gpm to 140 gpm operation each.

A rotary boom-type skimmer rakes solids floating on the primary clarifier onto a collection ramp containing a central well through which discharge of accumulated scum occurs. Cycling of the skimmer across the ramp is intended to raise the well plug, allowing scum and minimal extraneous water to drain by gravity to a scum pit. Later, manual capability for scum blowdown was also provided by plant personnel via a rope attached to the well plug, and is periodically employed by the operator on location. From the scum pit, collected floatables in slurry with wastewater simultaneously collected are pumped along with the primary sludge stream to the sludge holding tanks for temporary storage. The volume contributed to the primary waste solids stream by the scum fraction is comparatively minor as would be expected.

The other significant contributing wastewater solids stream originates in the secondary treatment module of the plant at the twin final clarifiers. Two 75-foot diameter circular upflow clarifiers operated in parallel provide final effluent polishing for flow coming directly from the aeration basins. No floatable solids capture and removal mechanism is presently provided on these clarifiers, but settled sludge is removed using vacuum uptake mechanisms. Polished effluent is discharged over peripheral vee-notched weirs, and flows to the chlorine contact basin for subsequent disinfection. Hydraulic loadings on the secondary clarifiers are relatively low, and the detention time of slightly less than three hours is adequate. Flow to the two secondary clarifiers is approximately equal and operational modes are identical.

Secondary sludge wasted from the two final clarifiers flows by gravity to the Secondary Recirculation Pumping Station and then can be pumped to the sludge holding tanks prior to treatment. Operational flexibility does exist, however, to recycle a fraction of the secondary sludge to the head end of the primary clarifier.

Two similar 275,000-gallon cylindrical anaerobic digester tanks for sludge stabilization were constructed as part of the original primary wastewater treatment plant facilities (Plate 2). Since that time anaerobic digestion of wastewater solids has been discontinued at the plant, and subsequent modifications of the plant facilities included conversion of these tanks to sludge holding basins. Stationary tank covers have been installed in lieu of the original floating covers, and the units are currently used to hold the mixed stream of primary sludge, primary scum and waste secondary sludge prior to processing. Present sludge treatment operations are not conducted on a continual basis, thus requiring these interim holding provisions. The size of the converted digester tanks is adequate to afford 11 days of sludge storage at average plant flow in the event of a breakdown in the sludge processing system, provided the tanks are empty at the time of failure.

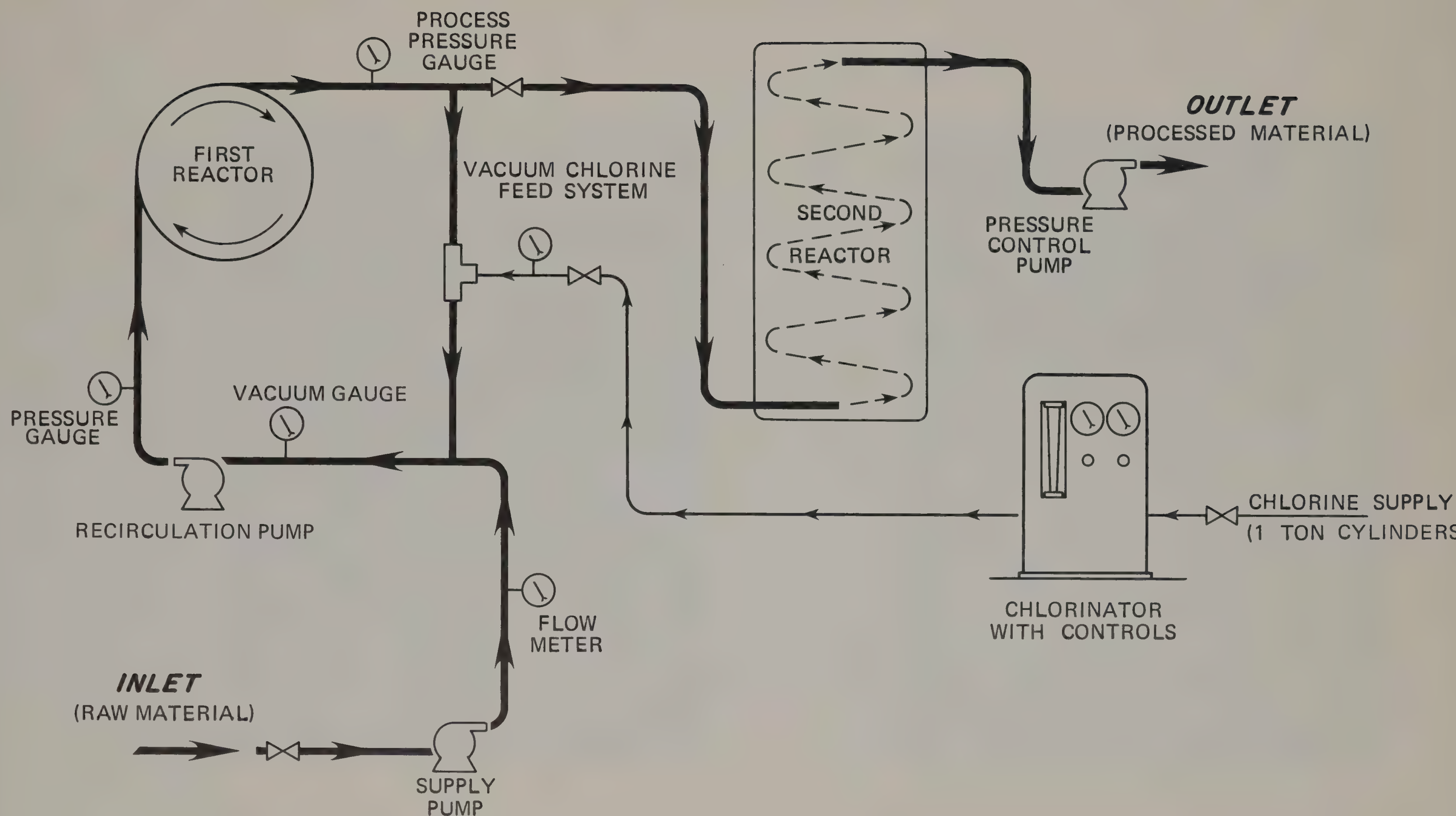
Conical bottoms exist in both of the sludge holding tanks, and the No. 1 tank is equipped with

limited internal mixing capability afforded by a single 300-gpm (approximate) pump. This is intended to promote mixing of stored solids, and prevent undue settling of solids from suspension. Thus the waste sludge stream is intended to be kept relatively homogenous to achieve optimum results from subsequent processing operations.

Sludge treatment for ultimate disposal of wastewater solids held in the existing holding tanks is accomplished using a chlorine wet oxidation process known by the proprietary name of "Purifax". This process, marketed by BIF, Incorporated, a unit of General Signal Corporation, involves exposing the raw sludge stream to an intense dosage of chlorine, a powerful oxidant, in aqueous solution. This is accomplished in a closed reactor under pressure conditions (30 to 40 gauge psi), and is intended to biologically and chemically stabilize and disinfect the wastewater sludge (Plate 3). A schematic of this process is shown in Figure 2.

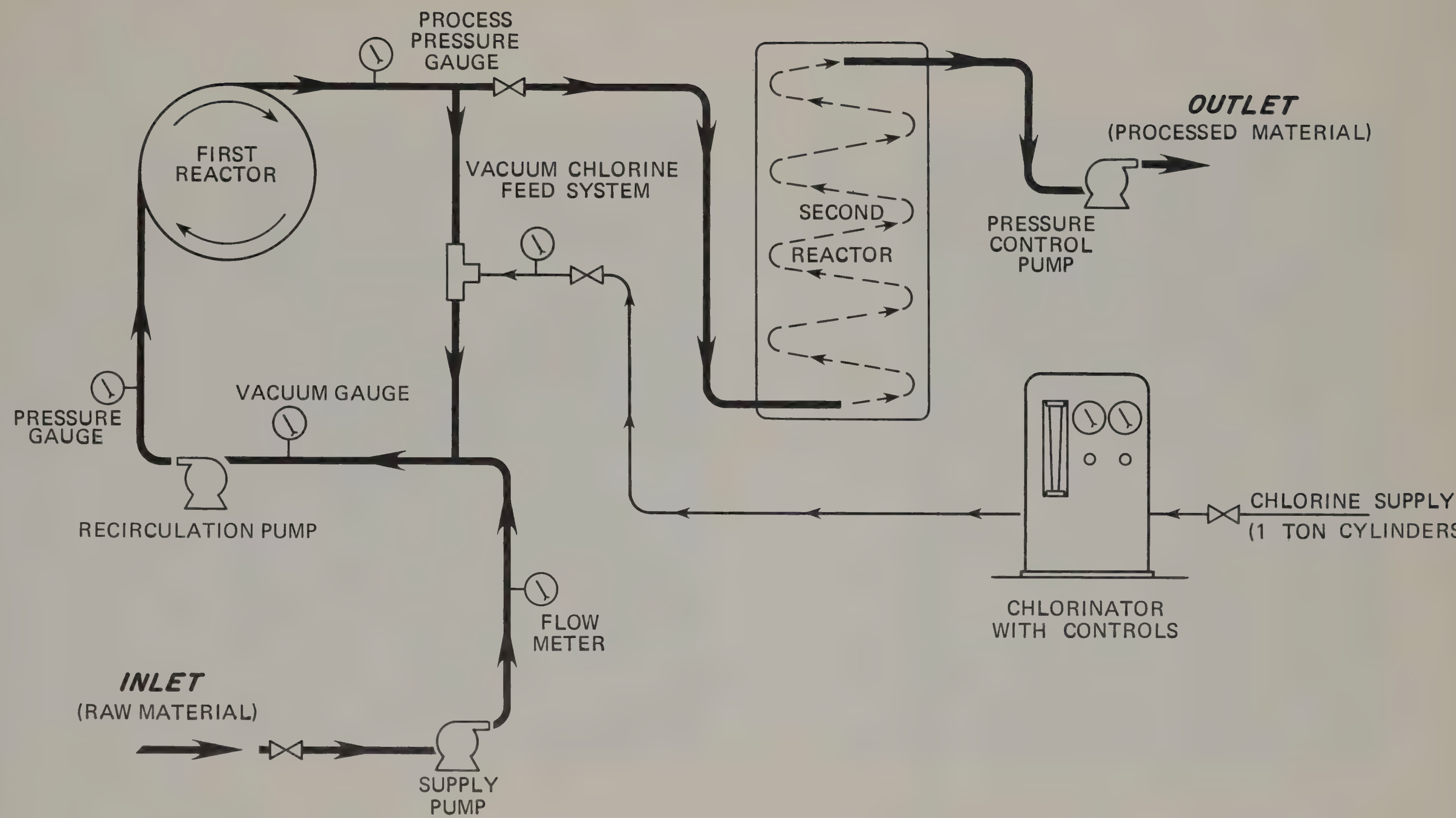
Processes such as Purifax are known as superchlorination treatment processes, and depend on the chemical behavior of chlorine in contact with organic materials which predominate in municipal wastewater sludges. In the process, gaseous chlorine is fed from one-ton pressurized cylinders (Plate 4) into a chlorinator device (Plate 5) which mixes the gas with fresh water forming a strong aqueous chlorine solution. In the presence of water, diatomic chlorine forms two chlorinated products: hypochlorous acid and hydrochloric acid. Upon contact with an organic solution such as sludge, each product serves a unique function in the process. The hydrochloric acid severely reduces the pH of the solution which affects further behavior of the process as well as killing a significant fraction of bacterial species present due to the formation of a strongly acid environment. The hypochlorous acid formed, along with its subsequent byproducts, oxidizes various organic components of the sludge and renders it innocuous. This latter phenomonon is accomplished in two ways: 1) Certain sludge components are stabilized or altered to make them unsuitable for bacterial consumption as food sources, and 2) other sludge components are altered to create compounds that exhibit toxic proper ties toward bacteria. Thus the Purifax process accomplishes sludge stabilization by blocking metabolic pathways by which bacteria are able to utilize organic materials in the sludge to promote biological degradation and further decay. Additionally, the process alters other physical characteristics of the sludge, making it less objectionable. Chlorine, the basis for familiar household bleach, also bleaches the sludge stream from its raw dark brown or black color to a tawny buff color. The odor is also drastically changed to a unique sweet, chlorine-suggestive smell, one that has proven to be offensive to citizens in or near the vicinity. Solids/ liquid separation is also reported by the manufacturer to be enhanced which can aid dewatering prior to further disposal operations such as sand bed lagooning or vacuum filtration.

Chlorine applied in the Purifax process is added in excess of oxidative requirements, hence the characterization of "superchlorination", with the intent of establishing a high free-chlorine residual



PURIFAX SLUDGE OXIDATION SYSTEM
(schematic)

FIGURE 2



PURIFAX SLUDGE OXIDATION SYSTEM
(schematic)

FIGURE 2

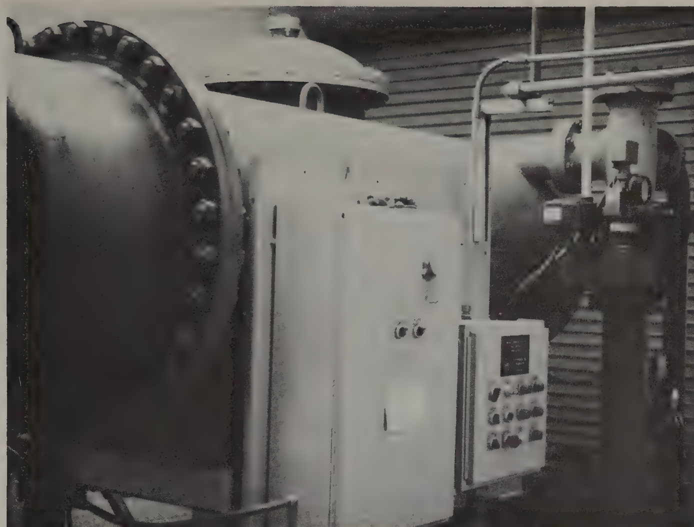


PLATE 3: Purifax sludge oxidation equipment housed in Sludge Oxidation Building; note first reactor visible in foreground and top of second reactor in background.

PLATE 4: Storage room for one-ton chlorine gas cylinders in Sludge Oxidation Building; Purifax machinery visible through doorway.

PLATES 3 & 4

PLATE 5: Chlorinator device to mix gaseous chlorine into aqueous solution prior to feed to Purifax oxidation equipment.

PLATE 6: Filled sludge drying lagoon; note pipe at right used to fill lagoon with freshly processed sludge.

PLATES 5 & 6

in the treated sludge. This serves to prevent the resumption of bacterial action that could cause subsequent decay and generation of associated foul odors. The manufacturer's recommendations are to provide a free chlorine residual in fresh Purifax effluent of 200 to 300 parts per million.

At the Helena facility one 108-gpm Purifax unit is housed in the Sludge Oxidation Building (Plate 3). This unit is intended to operate approximately one eight-hour shift per day including weekends, and processes an average daily flow of approximately 50,000 gallons. The processing is shown in schematic in Figure 2 (preceding). The solids content of this sludge stream fluctuates from three to four percent by weight, but on occasion has dropped to two percent. Chlorine is transported to the site in one-ton pressurized cylinders and held in a storage room at the south end of the building (Plate 4). An overhead bridge crane conveys cylinders individually on an as-required basis to the sealed chlorinator room for hookup and discharge to the chlorinator device (Plate 5). Water is piped in to form the aqueous solution which is fed under pressure to a central room housing the Purifax machinery.

The chlorine solution is introduced into the sludge stream immediately upstream of a pressurized reactor where circulation is introduced in a spiral pattern to promote chemical reaction. 30- to 40-gauge psi are maintained in the reactor and effluent flow is split, with the majority going to recycle through the initial phase of the process. The remainder is piped to a second reactor operated at similar pressure for completion of the oxidative process. Typical volumetric recycle through the first reactor is on the order of 90 percent, although this control parameter can be varied.

Upon discharge from the Purifax unit, treated sludge is pumped directly to dewatering lagoons (Plate 6). A network of ten lagoons of slightly larger than one acre each is now in service; recent construction has doubled the number of lagoons available. Sand liners have also recently been installed in the lagoons to promote percolation and expedite dewatering operations and provide an inert buffer zone above the soil (Plate 7). One of the lagoons is also equipped with a perforated PVC underdrain system to enable monitoring and analysis related to bed performance. The lagoons are operated on a rotational basis with treated sludge being pumped to an individual cell until a depth of approximately three feet has been reached. At that point discharge is switched to an alternate cell.

A combination of evaporation and downward percolation removes the bulk of the moisture from the lagooned sludge, eventually resulting in a leathery cake of residue. These dried solids are then amenable to equipment handling, and are raked from the bed with front-end loaders and trucked to a landfill disposal site. Present landfilling operations utilize a city-owned site restricted exclusively to sludge disposal lying immediately northeast of the wastewater treatment plant. Dewatered

PLATE 7 : Sludge drying lagoons showing newly installed sand liners to promote sludge dewatering.

PLATE 8: Filled sludge drying lagoon used for analytical tests including monitoring of free chlorine residual and lagoon stage; note stage measuring stake in foreground.

PLATES 7 & 8

solids are deposited in trenches excavated to an average depth of ten feet, and earth cover material is replaced at a typical thickness of at least two feet.

Increased interest in leachate monitoring from the sludge landfill prompted the installation of a series of monitoring wells in and around the site in 1979. This was performed by Hydrometrics, Inc. of Helena and will provide information regarding seasonal groundwater fluctuations as well as generation, content and movement of leachates. Comprehensive quarterly analyses are planned of monitored well waters to assess related environmental impacts.

The projected life of the present sludge landfill site will fulfill the City's needs well past the year 2000. Investigations are currently underway for extended land procural to meet future needs. Sites under consideration lie adjacent to the treatment plant to the north and northwest. Significant portions of these sites under consideration are currently in the private domain.

2. Hydraulic and Organic Loadings on Existing Solids Handling System

Loadings on the existing solids handling system at the Helena Wastewater Treatment Plant can be described in terms of both quantitative and qualitative parameters. Quantitatively speaking, the load on solids handling equipment is expressed in terms of the volume of wastewater sludge to be treated on a daily basis. The quality of this sludge stream can be described in terms of the actual mass of solids contained in the total flow. A sludge treatment process such as the current chlorine oxidation technique is aimed at stabilization of the solids contained in the sludge stream. Thus the qualitative parameters of actual solids mass along with indications of the relative organic content or oxidizable fractions contained therein are of primary importance. Sludge volume considerations are significant from the standpoint of the flow capacity of treatment equipment. The relative dilution or concentration of solids in the sludge stream afforded by the presence of extraneous wastewater is somewhat critical to chlorine contact processes such as Purifax due to the process' dependence on thorough contact between the oxidizing solution and oxidizable materials in the sludge.

Average quantitative and qualitative parameters observed in the wastewater sludge stream at the Helena plant are presented in Table 2. Due to changes in the quantity and strength of plant influent and variations in the biological process employed in the secondary treatment module of the Helena facility, these parameters show significant variability. The opportunity for limited solids/liquid separation due to inadequate mixing in sludge held in interim storage induces further variation in the daily characteristics of material reaching the Purifax oxidation equipment. The standard operational procedure of interim storage prior to processing thus prevents an exact characterization of the sludge stream. Consequently, the values presented in Table 2 are at best approximate averages over recent months of operation.

TABLE 2

EXISTING LOADS ON SOLIDS HANDLING SYSTEM

RECENT AVERAGES*

Parameter	Value
Average Daily Wastewater Flow (observed)	3.2 mgd
Design Average Wastewater Flow (daily)	6.0 mgd
Design Maximum Wastewater Flow (daily)	12.0 mgd
Primary Sludge Stream	
Daily Production	10,000 to 18,000 gpd
Solids Concentration in Primary Sludge	2% to 4% by weight
Weight of Primary Solids Produced per Day	2,000 to 4,000 lbs./day
Secondary (Waste Activated) Sludge Stream	
Daily Production (to disposal)	25,000 to 45,000 gpd
Solids Concentration in Secondary Sludge	1% to 2% by weight
Weight of Secondary Solids Wasted per Day	2,000 to 5,000 lbs./day
Combined Sludge Stream	
Daily Production	40,000 to 50,000 gpd
Solids Concentration	1.5% to 4% by weight
Weight of Solids Produced per Day	4,000 to8,000 lbs./day
COD, Total †	3,660 mg/l

* Values expressed are the result of consultation with plant operating personnel and examination of records for the last six months of 1979. Variations in the biological system employed for secondary treatment and the changes in sludge consistency induced by interim storage with minimal mixing necessitated the reporting of values as characteristic ranges.

† Value obtained from the analysis performed in triplicate on grab sample from No. 1 holding tank by Alden Beard on January 18, 1980 at treatment plant lab.

3. Performance of Existing Wastewater Sludge Handling System

The past performance of the existing wastewater solids handling system at the Helena Wastewater Treatment Plant has been the subject of recent controversy, particularly with respect to sludge dewatering and disposal activities. It has been further observed that with respect to the present Purifaxing operation, certain performance data has been unavailable up to this time, and some data distributed by the equipment manufacturer has been criticized as inaccurate or incomplete. Thus a comprehensive investigation was launched to evaluate the performance of the existing sludge handling system, and a supplemental analytical testing program was implemented.

Several performance problems associated with wastewater solids capture and removal mechanisms at the Helena treatment plant were cited in the original Facilities Plan and are worthy of summary here. These deficiencies concern preliminary, primary and secondary treatment processes at the plant, and thus indirectly affect solids handling operations.

i. The two comminutors operated in parallel as part of the preliminary treatment module of the plant posed a maintenance problem and complicated further treatment operations. In particular, rags and fibrous materials ground up in these devices caused subsequent plugging problems for the spray nozzle system atop the ABF tower of the secondary treatment system. Additionally, fibrous materials have caused flow blockages along the vee-notched overflow weir of the primary clarifier; this has required the regular cleaning of the weir with high-pressure fire hose equipment. In the past month one of the comminutor units has been replaced with a pair of manually cleaned bar screens with two-inch and one-inch openings, respectively. It is expected that immediate improvements will be observed due to the removal of the rag and fibrous fraction of the incoming waste collected on the screens.

ii. Scum removal capability on the existing primary clarifier has been cited as ineffective and troublesome. Despite the capability for manual operation of the scum blowdown equipment, the removal of floatable materials has not been reliable or satisfactory. This has contributed to the plugging problems described above associated with the vee-notched primary clarifier weir and the ABF tower distributor nozzle system. The original cam-activated automatic scum blowdown system is frequently supplemented with the manual override capability, but plugging of the blowdown pipe which must be used in either case continues to pose a problem. Furthermore, a significant quantity of extraneous wastewater is removed along with the captured scum, introducing unnecessary hydraulic load on solids storage and processing facilities.

iii. The existing primary clarifier is presently overloaded, and as plant flows increase in the future with increasing population and subsequent wastewater generation, performance will continue

to decline. It was strongly recommended as part of the original Facilities Plan that a similar additional primary clarifier be added to improve performance and add backup capability in the event of failure of one unit. The practice of recyling of a fraction of the waste-activated sludge from the secondary treatment process to the head end of the primary system added further stress to the already overloaded unit. However, recent piping additions have provided an alternative to this practice, and allow waste-activated sludge to be transferred directly to the sludge holding tanks. According to the Plant Operator, the practice of recycling to the primary clarifier has been discontinued indefinitely.

iv. The secondary clarifiers, while of adequate capacity, are not presently equipped with scum removal apparatus. Addition of such equipment has been twice proposed, but has not been approved for funding assistance by the EPA. The addition of suitable skimming equipment to the final clarifiers or, alternatively, to a suitable chamber of the subsequent chlorine contact basin is recommended.

While these problems do not have a substantial effect on the operation of subsequent solids storage, processing and disposal operations, they do impede optimum operation of the Helena wastewater treatment process as a whole. Thus these related solids capture and removal operations are important considerations in the overall task of wastewater solids management.

The heart of solids handling operations at the Helena Wastewater Treatment Plant involves the following facilities, which will be looked at from a performance standpoint in the following section: the sludge holding tanks, which provide interim storage for the collected solids stream prior to processing; the Purifax sludge oxidation equipment; the sludge dewatering lagoon network; and the dried solids landfill site. Additionally, the results of the analytical testing program implemented to ascertain performance characteristics of some of the system components will be described in detail.

a. Sludge Holding Tanks

The existing twin 275,000 gallon tanks for interim sludge storage prior to further processing were originally used as anaerobic sludge digesters when the Helena Treatment Facility was restricted to primary wastewater treatment. Up to ten days of raw sludge storage is afforded at average daily flows, and the tankage available is typically used to at least half capacity. This has been due at least in part to reliability problems associated with subsequent processing equipment that have required frequent stockpiling of sludge. Under ideal operating conditions, a comfortable standby capacity is afforded by the holding tanks that would allow a reasonable downtime margin for the downstream processing machinery.

The sludge holding tanks are hydraulically connected and typically operated in series such that sludge for processing usually comes directly from only one of the two units (Tank No. 2). A small mixing pump is available to serve either of the holding tanks individually; however, it is generally employed on the No. 2 tank feeding the Purifax system. This provision is intended to minimize solids/liquid separation within the tank and to promote a homogenous feed to the processing equipment. The pump, which has lost capacity with age, can presently only circulate a maximum of approximately 300 gpm. When compared with the total volume of one tank (275,000 gallons), a tremendous inadequacy is apparent. This is substantiated by the regular experience of plant operating personnel which indicates that initial withdrawal from a tank containing half capacity or more of sludge is generally very watery in nature. A very thin sludge stream will continue to predominate for several days when the tank is being drawn down from a nearly full stage. Eventually the sludge begins to thicken as withdrawal continues, with the final fraction being very heavy and thick. Due to the dependence of adequate chlorine feed in the processing equipment on the solids content of the sludge, this changing pattern of increasing sludge concentration causes operational problems and requires constant attention by operating personnel. With internal mixing capability diverted to the No. 2 tank, a similar separation phenomonon occurs in the No. 1 tank, compounding the problem. Greatly increased mixing capabilities in both holding tanks would improve the situation, and downstream sludge processing operations would likewise undoubtedly benefit.

b. Purifax Sludge Oxidation System

The Purifax sludge oxidation process is by nature a chemical-intensive one. Gaseous chlorine feed to form the aqueous oxidizing solution is on the order of one-half ton per day. Due to the problems with varying consistency in the raw sludge feed as described above, the chlorine feed requirement to obtain a satisfactory effluent residual (200 to 300 ppm) fluctuates significantly; the usual range falls between 350 and 500 lbs./day. It is intended under normal operation that the oxidizing equipment run one eight-hour shift per day, seven days per week. At the present delivered price for chlorine gas of $.12/lb., the annual operating expenditure for chlorine for the Purifax units is approximately $18,000.

The necessity in the Purifax process of providing chlorine in excess of oxidative requirements requires that the process be monitored closely. Several important considerations must be balanced to achieve optimum performance in the system:

i. Sufficient chlorine must be present to completely oxidize organic material in the raw sludge and additionally provide an effluent residual of 200 to 300 ppm. This requirement varies almost directly with the solids content of the raw feed, which exhibits wide fluctuations, as previously discussed.

ii. Extreme overdosing of chlorine to assure fulfillment of instantaneous peak demands is extravagant and costly, recognizing chlorine costs.

iii. Overdosing of chlorine results in a significantly higher effluent chlorine residual than the 200 to 300 ppm desired range. This has been suspected as a contributing cause to the generation of offensive chlorine odors, recognizing the unpleasant odor associated with high concentrations.

In response to these considerations, treatment plant personnel currently test the free chlorine residual of freshly processed effluent on an hourly basis using a Hach Chemical Co. test kit procedure. Depending on the results obtained, a direct adjustment to the chlorine feed can be made. Additionally, a Standards Methods Free Chlorine Residual Analysis is made in the plant laboratory at least once per day to verify the test kit results. Agreement between results of the Standard Methods and the test kit procedure is not precise, but the discrepancies observed are consistent enough to allow use of the latter method for Purifax process adjustment. Unfortunately, with the present raw sludge mixing provisions in the existing holding tanks, chlorine demand fluctuates more rapidly than it would be feasible to monitor. Thus these mixing problems should be corrected if operation of the Purifax system is to be optimized.

The Purifax system necessarily requires specialized equipment and handling provisions due to the highly corrosive properties of chlorine. However, such provisions have not been without fault. Corrosion of metal machinery surfaces, chlorine feed pipelines and electrical control circuitry has been a serious maintenance problem. The neglect of certain maintenance duties in the past caused numerous component equipment failures, resulting in mediocre operation of the Purifax system as a whole. However, an intensified maintenance program for sludge oxidation equipment recently implemented by the City has been very successful in remedying past deficiencies. Significant cost and effort have been expended from mid-1979 to date to acquire additional competent personnel and expand knowledge of the Purifax operation. The results of this intensified effort have been impressive, and have thus far included repair and replacement of piping systems and electrical circuitry, cleaning and repair of equipment, replacement of various Purifax equipment components, and numerous other site improvements. However, a significant number of component failures continue to plague the system.

In the course of the analytical testing program implemented as part of this study a number of significant component failures were encountered that resulted in temporary delays in obtaining samples for analysis. While perhaps not representative of the operational capabilities of the system, these

problems, as summarized below, do reflect the maintenance-intensive nature of this type of equipment. It should be noted that the following breakdowns occured despite the recent implementation of an intensified maintenance program for solids handling machinery.

November 13 through 16, 1979: Purifax system down for repairs; loss of vacuum on chlorine feed system prevented chlorine introduction to system reactor; repiping and other repair necessary; this failure encountered in trying to obtain Purifax sample for nitrogen assays.

November 29 through December 5, 1979: Purifax system down for repair; automatic controller had sheared square PVC stud on plastic ball valve; part order was necessary and delivery time slow; this failure encountered in trying to obtain Purifax sample for GC/MS scan for volatile organics to be performed by Lauck's Laboratory of Seattle, Washington.

December 14 through 19, 1979: Purifax system down due to broken manifold plate; part order thought to be necessary, but repair kit with necessary repair part located at plant and repairs proceeded relatively quickly; extensive dismantling of Purifax machinery required; this failure encountered in trying to obtain additional Purifax sample for Lauck's Laboratory.

January 21, 1980: Hole has developed in fiberglass pump casing that is part of Purifax machinery; chlorinated sludge is seeping from casing; system remains in operation because sludge holding tank capacity is close to exhausted and additional sludge must be treated before the Purifax system can be taken out of service for the necessary repairs; part order is anticipated; this failure encountered in procuring Purifax sample for activated carbon batch tests for odor control

It should be further noted that such failures require the interim stockpiling of raw sludge in the holding tanks and require later double- or triple-shift operation of the Purifax system to empty storage and compensate for incurred downtime. With only approximately 11 days of raw sludge storage available, repair of such failures is very urgent. This is often complicated by the necessary of obtaining certain proprietary parts from the manufacturer's outlet on the East Coast.

The availability of only one Purifax oxidation system at the plant poses a serious reliability constraint to future plant operations. As cited in the original Facilities Plan, the acquisition of an additional

similar unit should be contemplated at least by the year 1985. This is necessary to handle increased wastewater and subsequent sludge loads in the future. It is further mandated to provide adequate backup capability to the existing unit in the event of a failure. The latter consideration is accentuated by the somewhat failure-prone past performance of the existing system. The operator attention required by the Purifax unit when processing sludge precludes the option of around-the-clock operation of the existing unit to meet future increased demands without increasing plant staff. Obviously, 24-hour-per-day operation would not allow any backup capability, and would also be likely to increase the frequency of equipment failures.

A significant part of the performance evaluation of the Purifax unit is related to the chemical analyses associated with the testing program implemented as a part of this study. The evaluation of these results as they pertain to the oxidation process are reported in a following section (p.19).

c. Sludge Drying Lagoons

Upon discharge from the Purifax equipment, processed sludge is conveyed by an underground piping system to a network of ten diked drying lagoons. Sludge has typically been deposited in the beds to a depth of several feet, the level of which subsides due to evaporation and percolation of the associated liquid. Recent improvements have been implemented to increase the area of available lagoon space from approximately five acres to more than eleven acres. The system is currently comprised of ten individual cells, allowing good flexibility in the operation. Of the ten cells, nine are designated for direct receipt of sludge, with the additional lagoon serving as a receiving point for subnatent drained from the other cells. The transfer of supernatent is done on occasion to promote rapid percolation of relatively solids-free liquid and thus reduce the opportunity for the generation of offensive odors. This practice, however, has proven to be troublesome due to the use of portable pumping equipment, and the positive effects have been minimal. The recent addition of sand liners in the lagoons, coupled with a reduced depth of sludge deposition, have been somewhat successful in promoting expedient dewatering operations. The experimental addition of a PVC piped underdrain system in the sand liner of one lagoon cell has demonstrated improved effects on dewatering time due to continual removal of percolating water, thus preventing flow impedance by saturation of the underlying soil strata. This trial installation would suggest, in conjunction with the continued operation of the existing lagoon dewatering system, complete underdrain systems for all lagoon cells directly receiving sludge as being of benefit. The underflow contribution from each of these individual cell systems could be piped to one or two specialized receiving cells designated exclusively for lagoon subnatent, or recycled through the plant.

The lagoon dewatering system has been the focal point for much of the recent controversy

regarding the generation of odors offensive to nearby residents. The nature of such a lagoon system depends to a large extent on the exposed surface area at which evaporation occurs. This also affords a great opportunity for volatile and odorous materials to enter the airspace and be conveyed by prevailing winds. The odor of freshly Purifaxed sludge as discharged to the lagoons is not purported by the equipment manufacturer to be offensive. However, public experience, particularly during the summer of 1979, has proven to the contrary. Residents and passers-by within more than a two-mile radius of the treatment plant have repeatedly complained about dissemination of putrid odors from the facility. Depending on prevailing air currents various adjacent residential and commercial districts have been afflicted.

Investigations and public experience have pinpointed the dewatering lagoons as the primary odor source. Other odor sources are undoubtedly present in association with the wastewater liquid treatment process; however, the unique, readily identifiable odor of Purifaxed sludge leaves little doubt that the problem ultimately rests with the lagoon system. Due to a rash of inopportune maintenance problems early in 1979, a large volume of sludge was stockpiled in the holding tanks and received only marginal oxidation treatment through the Purifax unit. When this improperly handled sludge was deposited in three of the lagoon cells, it was suggested that bacterial decay resumed rapidly, and reputrescence of the sludge was the cause of the summer's odor offense. Once these beds dried and the solid residue was landfilled, however, offensive odors and complaints thereof recurred periodically. It is possible that subsequent odor generation was less intense; however, public reaction established that the situation continued to be unsatisfactory.

It also became obvious from day-to-day contact with both freshly Purifaxed sludge and lagooned materials during the course of the analytical testing program that the characteristic Purifax odor has little relationship to lagoon residence. Freshly processed material obtained directly from the unit at optimal operation exudes the same odor that has permeated adjacent residential areas and caused public outcry. Lagoons receiving properly stabilized sludge demonstrate similar odor generation, and reported differences in odor are largely a matter of degree.

Much of the odor controversy reduces to a matter of conflicting land uses forced into uncomfortably close proximity. Conventional wastewater treatment and sludge stabilization inherently results in the generation and dissemination of certain offensive odors. At the time the Helena treatment plant was originally located, it was adequately distant from any residential or commercial development. However, as urban sprawl penetrated the Helena Valley, the facility has become almost encircled with development, and the spatial buffer zone has been drastically reduced. Thus the distribution of any offensive odors is almost immediately sensed. The problem becomes especially acute

during summer months when house windows are open and outdoor activity is highest. Winter freeze-up of the dewatering lagoons reduces and on occasion eliminates odor release due to an effective ice seal of the lagoon contents.

Odor generation is related largely to the presence of liquid in conjunction with the sludge solids in the lagoons. Once the sludge solids have completely dried, widespread odors decline significantly. This aspect of the problem was the impetus for the installation of sand liners and the one-cell underdrain system in the lagoons to promote rapid dewatering. As reported by the Purifax manufacturer, the oxidation process causes sludge solids to initially float due to the release of gas bubbles from the depressurized solution. The floating phenomonon is only transient, and solids settle to the bottom of a lagoon within hours. This forms a gelatinous solids mass across the lagoon floor and significantly impedes the further passage of percolating liquid. When employed, the transfer of lagoon supernatent to a special lagoon cell set aside for this exclusive purpose has circumvented this problem to a degree, but had little odor-reducing impact.

Performance characteristics of the lagoon dewatering system are reported in a later section (p.21).

d. Sludge Landfill

The landfill used as a final repository for dewatered sludge solids has experienced minimal known operational problems. The present 40-acre site has a projected life adequate throughout the planning period under present operational procedures. Increased interest in potential leachate contamination to underlying groundwater has prompted the installation of a significant number of additional monitoring wells in and around the site with comprehensive water quality analyses to be performed quarterly. This will enable close scrutiny of environmental hazards, and will allow expedient changes in present practices, should they be required.

Although no information is directly available concerning leachates from this site, the chemical content of the solids fraction of the sludge as documented in conjunction with the analytical testing program report indicates that strict monitoring is advisable. The clay loam soils interbedded with sands and gravels at the site constitute a relatively well-drained soil matrix. Thus percolating precipitation in contact with the dried solids could conceivably generate chemically diverse leachates. Proper landfill practices and surface maintenance are mandatory to promote rapid overland drainage of the immediate area and minimize infiltration opportunities.

e. Analytical Testing Program

The analytical testing program implemented as part of this study was divided into four

sections: 1) general chemical analyses of various components of the wastewater and associated solids streams to assay specific significant metals, other ions and organic load parameters; 2) volatile organics analysis of Purifaxed sludge for odor-causing compounds; 3) monitoring the level of free chlorine residual and liquid stage in a recently filled lagoon cell; and 4) activated carbon batch tests for odor control. The tabulated results appear in the following respective appendices:

Appendix 2:	Description of Analytical Testing Program and Results of General Chemical Analyses
Appendix 3:	Results of Volatile Organics Analysis
Appendix 4:	Results of Lagoon Stage and Free Chlorine Residual Monitoring
Appendix 5:	Results of Activated Carbon Batch Tests

An evaluation of these results follows.

Heavy metals concentrations demonstrated to occur in the raw sludge are comparatively high, particularly for some of the more troublesome species. This is somewhat surprising in light of the absence of extensive industrial waste contributions in the Helena area. Zinc and copper appear in by far the greatest concentrations, in the range of 50 ppm each. Both of these metals are essential dietary elements for humans and animals at trace levels; however, higher dosages can be toxic. Toxic properties of both metals when found in water are inversely related to the hardness of the water, due to the formation of a less harmful complex between the metals and hardness-causing ions.

The levels of nickel, chromium (total), lead and cadmium are also high in the raw sludge, although their absolute concentrations as compared to those of zinc and copper are much lower. Due to the inherent properties of various heavy metals and the mechanisms by which they exhibit toxic effects toward living organisms, what is deemed a noteworthy concentration of one species is not necessarily so for another. The presence of cadmium is especially significant due to current EPA guidelines stipulating that concentrations of this element directly govern allowable applications of sludge to land disposal systems (ref. Federal Register 44:179, Sept. 13, 1979). In anticipation of the occurence of heavy metals in the sludge stream, samples of raw wastewater were also analyzed from the three major sewer trunk lines serving the municipal area. These results showed the contribution from one trunk (Harris Street) to contain appreciably higher metals concentrations by factors ranging from 50 to 400 percent. This trunk services the only industrial contributors in the service area that conceivably could be discharging wastes containing high heavy metals concentrations. While the detection limits of the atomic adsorption spectroscopy techniques used for these metals assays were exceeded for cadmium, chromium, mercury and nickel in these trunk line samples, the trend is obvious from the results obtained for lead, copper and zinc. Three grab samples obtained on a Tuesday

(3:00 p.m.), Friday (noon) and Monday (5:30 a.m.) were composited for each trunk line in an attempt to include any irregular sludge discharges to the collection system. Results of these analyses are somewhat tentative, but indications are adequate to justify additional monitoring of heavy metals contributions along this trunk line. The issue is critical due to the controlling nature of cadmium content to allowable sludge application in land disposal systems.

An additional source suggested for the presence of high metals concentrations in the wastewater is their introduction through the municipal water supply or domestic uses thereof. Analyses on file with the Water Quality Bureau of local supply sources indicate that the potable local supply contains little or no detectable concentrations of the metals of concern. This was expected in light of state and federal water quality standards. A further possibility does exist, however, that with respect to zinc, copper and lead, domestic water piping and the occurence of a limited number of copper sewer service connections in the municipal service area are contributing these metals to the wastewater stream. The corrosive environment often present in sewer pipes could induce significant dissolution of such metals. The City has replaced the majority of such old sewer services; however, they acknowledge that an unknown number are still in use. It is doubtful, nonetheless, particularly in light of the preponderance of metals occuring in only one of the three central trunk lines, that contributions of metals from domestic sources are of major significance.

Additional heavy metals analyses of sludge freshly processed through the Purifax system indicate approximately a 25 percent reduction for each species. There is nothing about the chlorine oxidation process nor other conventional sludge treatment processes that would actually reduce the total amount of metals present. However, the low pH conditions of the Purifax process would tend to dissolve an appreciable fraction of any metals found in a solid phase or in conjunction with sludge solids. Thus dissolved metals could be anticipated to increase, relatively speaking, and suspended metals could be expected to decline. The analytical procedure employed involved a laboratory digestion of each sample to force all metals present into their dissolved phases to facilitate quantification. The phase shift induced by Purifax treatment most likely altered the amenability to detection of a certain fraction of each metal present. Thus the apparent decrease in metals concentrations caused by Purifaxing is presumed nonexistent, and is attributed to experimental detection error.

Lagoon underdrain water analyzed demonstrated consistency with the preceding conclusion. Of the cadmium, copper, nickel and zinc concentrations present in the freshly processed material, more than 50 percent was detected leaving the lagoon system through the relatively solids-free underdrain water. This indicates a high fraction of each of these species was solubilized, and remained so. The same was not true of lead, mercury and chromium, but their comparatively low solubility explains this. Manganese was substantially increased in the underdrain water, but this element is relatively innocuous, and its occurence is likely related to a soils leaching phenomenon.

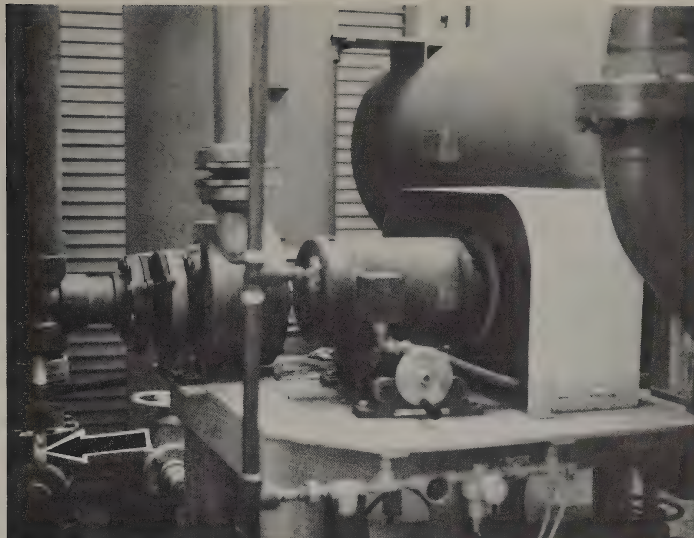


PLATE 9: Purifax machinery showing two reactors and sampling pipe (arrow) to obtain freshly processed sludge; samples of freshly Purifaxed sludge were obtained at this point.

PLATE 10: Sludge drying lagoon receiving underdrain piping effluent from adjacent lagoon; note PVC underdrain outlet pipe in foreground; samples of underdrain water obtained at this point.

A question is raised, however, regarding the groundwater contamination hazard posed by the demonstrated presence of cadmium, copper, nickel and zinc. It can be assumed that water discharged from the lagoon underdrain system (Plate 10) is representative of that free to percolate into the underlying soil strata. Fortunately, the cation exchange capacity for soils in the area is reportedly high, based on local Soil Conservation Service tests. Thus metals, typically occuring as cations, are likely to be assimilated in significant quantity by the soil particles as they pass through. This substantially reduces the possibility of groundwater contamination. A further safeguard is afforded by the fact that of all the heavy metals demonstrated to be present in the underdrain water sample, none of the concentrations present would require dilution in the groundwater by a factor larger than 100 to bring them into compliance with EPA guideline criteria for potable water! Thus the concentrations, while relatively high in themselves, do not pose a serious direct environmental hazard.

The issue of excessive chlorides discharged to the environment has been raised in conjunction with the Purifax system, and was investigated. Analyses on file with the Water Quality Bureau obtained in 1978 and 1979 on supernatent from sludge lagoons indicate that chlorides are indeed high. Due to the high solubility of such anions, the bulk of their occurence would be anticipated in conjunction with the liquid fraction of the processed sludge, and the results of their analyses are valid. The nature of the chlorine oxidation process allows great potential for chloride creation, and municipal sludge is known to contain significant concentrations even in its raw state. The levels demonstrated in the lagoon supernatent, while high, do not constitute an environmental hazard under present methods of operation and disposal. The most important ramification of these results is the limitation posed to a land disposal system that would utilize soil incorporation. A high chloride waste such as the Purifaxed sludge, when incorporated into the soil, would increase soil salt content to an undesirable level for beneficial agricultural uses. Obviously, the acidic pH tendencies of the processed sludge also preclude direct incorporation without some sort of remedial buffering treatment such as lime addition.

Nitrogen assays performed as a part of this analytical testing program suggest several interesting conclusions. The question of nitrate contamination of groundwater aquifers from Purifaxed sludge dewatering and disposal activities has been raised in the midst of the public odor controversy. Ammonia nitrogen, which is a common and significant constituent of human and thus municipal waste, is apparently oxidized to a degree by the Purifax oxidation process, as would be expected. Ammonia nitrogen concentrations decreased through the Purifax process by approximately 25 percent. This was reflected in a corresponding increase of nitrite plus nitrate concentrations of greater than 15 times. The difference in percentage decrease of the former and the percentage increase of the latter is attributable to comparative molecular structures of the two nitrogen compounds involved in the oxidation reaction. The nitrates in the lagoon supernatent, however, are low enough as to

pose no direct hazard. Most nitrate present in the processed sludge would be in the liquid fraction due to its high solubility. Whether additional significant nitrate concentrations are being released in leachates from the dried solids landfill is uncertain at this time, but should become obvious through the test well monitoring program implemented in conjunction with Hydrometrics. The substantial organic nitrogen available in the Purifaxed sludge as reflected by its high Total Kjeldahl Nitrogen (TKN) suggests that adequate nitrogen remains in the solids fraction. Once landfilled, however, the opportunities for nitrate formation which requires oxygen and bacterial action for the oxidative process are reduced.

A volatile organics analysis was performed on freshly Purifaxed sludge to attempt to pinpoint the odor-causing compound(s) based on the assumption that the problem ultimately involved creation of a quickly volatizing, readily dispersing product in the process. From this standpoint the analysis was unsuccessful. Despite the identification of numerous volatile organics in the sample, their chemical complexity and unfamiliarity prevented the determination of any of them as the cause of the troublesome odor. The Purifax odor is a chlorine-suggestive one, and a number of the volatile organics identified have obviously been substituted with chlorine by the process. However, the human nose surpasses the sensitivity of the analytical equipment utilized many times over. Thus while one of the compounds identified may be at the root of the problem, there is an even greater probability that the compound(s) responsible are present at a level that escapes detection. This was the basis for a subsequent recommendation by Lauck's Laboratory that a large volume of air directly above a filled lagoon be pre-concentrated for further analysis. This is an option that the City might want to pursue, should the odor problem continue.

A further possibility that is not addressable directly without the expenditure of significant time and money is that the odor lies with what is considered to be a non-volatile compound. The designation of "volatile" in organic chemistry is a very relative one, and the human nose is sensitive to numerous materials that do not bear this label. The results of a partial characterization study of organics in superchlorinated sludges performed by the EPA in 1978 (EPA - 600/2-78-020) were thoroughly evaluated for non-volatile compounds that might cause the unique odor. No success was obtained, again due to the chemical complexity and unfamiliarity of the materials identified. Recognizing the odorous nature of phenolic compounds and their demonstrated occurence in the aforementioned study, laboratory samples of two chlorinated phenols were obtained and screened. However, while odorous, this class of compounds obviously is not causing the controversial odor.

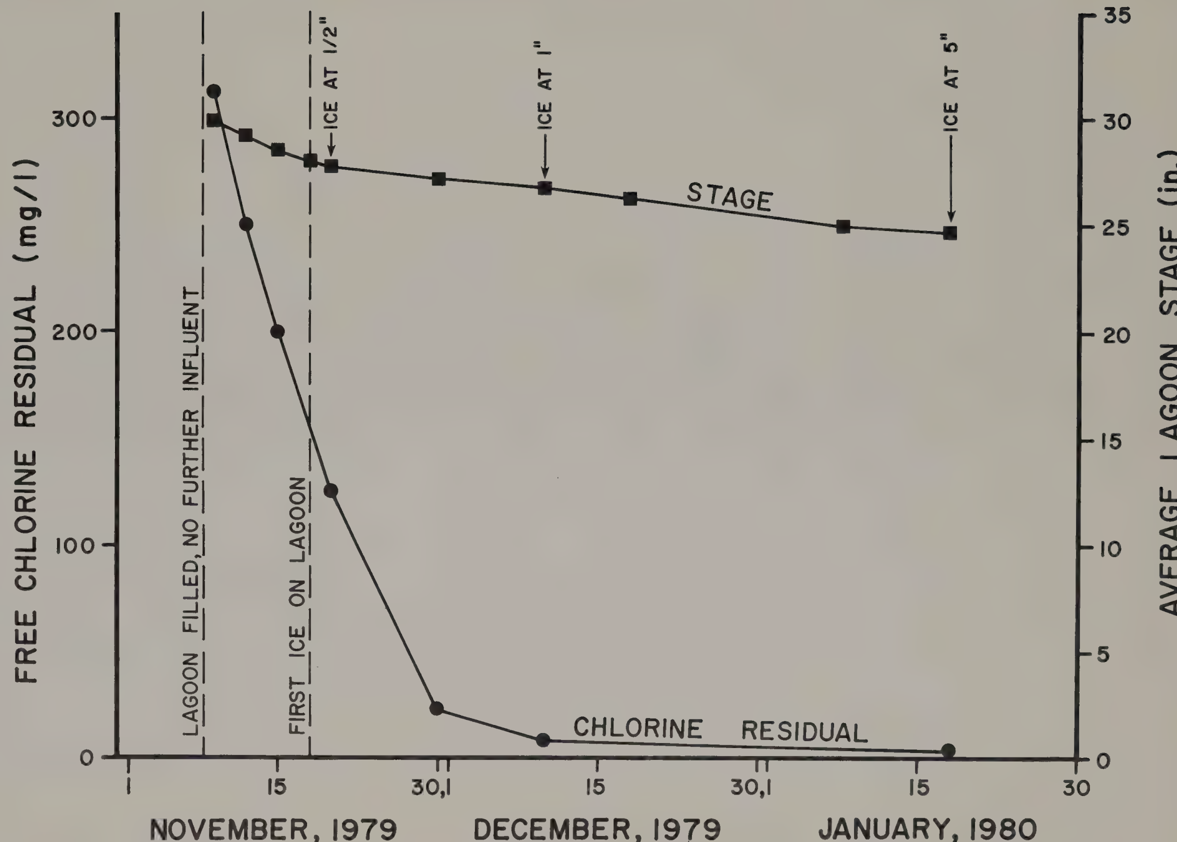
A noteworthy sidelight to the volatile organics analysis of the Purifaxed sludge was the demonstrated presence of several EPA-designated Priority Pollutants. While concentrations detected were all well within EPA tentative standards for disposal or discharge, it is evident that certain highly

toxic substances are present in the processed sludge. The presence of chlorine in several of these compounds leaves little doubt that their formation is directly related to the Purifax process. Certain of these compounds are suspected carcinogens, but unfortunately definitive criteria are not yet available from the EPA regarding creation or disposal of any of the Priority Pollutants. An intensive research program has been underway for the past two years to develop standards in this regard, and final conclusions are anticipated late in 1980. Guidelines published in 1979 are only tentative, and have been published for public comment. By nature, 65 compounds have been designated as Priority Pollutants due to their alleged highly toxic potential. Priority Pollutants are not necessarily organic chemicals; the heavy metal, cadmium, bears this designation also, and is furthermore being investigated for carcinogenic potential.

It should also be noted that of the 65 Priority Pollutants cited, a small majority are volatile organic compounds; the majority are non-volatile. A complete, although expensive, analysis is available from independent laboratories for the full spectrum of Priority Pollutants. This is an option worth considering if the present system of sludge treatment and disposal is to be continued. Despite the ominous picture presented of the Priority Pollutant compounds, it is also noteworthy that these same substances are present in trace quantities in most surface watercourses on the continent.

Enough questions have been raised regarding the environmental ramifications of disposal of superchlorinated municipal sludges, particularly with respect to the creation of Priority Pollutants, that the EPA has implemented an intensive research program regarding this stabilization method. The results of this investigation should be available late in 1980, and are expected to contain a definitive position, either favorable or unfavorable, by the agency on the future of the process.

An additional aspect of the analytical testing program involved the monitoring of free chlorine residual and liquid depth in an individual lagoon cell immediately after filling operations ceased. It should be noted that a permanent ice cover formed on the lagoon cell approximately ten days after this phase of the program began. This was inopportune, and obviously biased results of both parameters due to the elimination of opportunity for free chlorine dissipation or liquid evaporation to continue at the liquid/air interface. The results of this monitoring program are plotted in Figure 3 . The disappearance of free chlorine progressed steadily and was essentially complete within 30 days. This is consistent with results reported by the Purifax equipment manufacturer, and would be expected as oxidation of remaining organic material continued within the lagoon. The residual remains sufficiently high, however, to preclude the resumption of bacterial decay for at least a one-month period. This substantiates the premise that the inherent odor of the processed sludge is not biologically related, and further suggests that optimum dewatering time for a lagoon cell is on the order of one month. Otherwise the risk of further decay could be presumed, with the inevitable



CHLORINE RESIDUAL & LIQUID STAGE IN LAGOON

FIGURE 3

creation of additional, although probably different, noxious odors.

The presence of a surface ice seal appeared to have negligible effect on the decline of the free chlorine residual in the cell, although a definite effect was discernible in the rate of liquid state subsistence. At the initial rate of stage decline before freezeup, liquid level dropped approximately two inches in ten days. At such a rate, only a six-inch sludge application per lagoon cell would be allowable to achieve complete dewatering within one month. No supernatent was pumped from the monitored cell throughout the program; however, it was obvious that settled solids formed an effective seal at the bottom of the cell and undoubtedly severely impeded liquid passage.

Due to the inability of any chemical anlyses to pinpoint the odor-causing compound(s) in the Purifaxed sludge, a remedial approach to the odor problem was investigated. Recognizing the odor-absorbing properties of activated carbon, a series of batch tests were performed using powdered activated carbon to attempt attenuation of the odor once created, if possible. The results of the tests were successful; however, from a cost standpoint the process would not be economically attractive. It was found that a dosage of one percent by weight drastically reduced odor emission, resulting in a relatively innocuous product. Application of four percent by weight completely eliminated all odors from the solution. At the current market delivered price of $.25 per pound, the daily cost of a one percent additive would be in excess of $1,000, if the carbon were to be wasted. Provisions for reclamation and regeneration of the carbon would be very capital- and operation-intensive, and not practical for the Helena facility.

While precluded as a practical continual measure, powdered activated carbon addition could provide a viable crisis control measure if a particular lagoon cell(s) was pinpointed as causing an odor problem. Such an occurence was suggested in conjunction with the dewatering of improperly stabilized sludge during the spring of 1979. In such an event, carbon could be applied to the surface of the troublesome cell where it would tend to float. A blanket could be created across the lagoon cell surface creating a filtering barrier to absorb the odors on release. The dosage applied could be well below the one percent level; the quantity required would only be adequate to create an uninterrupted blanket a few tenths of an inch thick. On this scale of application the activated carbon process could have some definite merit.

4. History of Controversy Involving Current Solids Management Practice

A somewhat extensive history of controversy has surrounded current solids management practices at the Helena facility, and on occasion legal proceedings have evolved. Numerous press accounts have documented the public outcry against the odor offense. Additionally, an article contained in a recent journal (ref. "Sludge" Magazine, October 1979) contained a castigating review of sludge

superchlorination processes. This somewhat one-sided presentation is to be rebutted by the Purifax equipment manufacturer in the February issue of the same journal.

On a local scale, the public controversy has precipitated two separate legal proceedings in the past year. In mid-1979 a civil suit was filed in Justice of the Peace court against the City Manager alleging public nuisance. The case was initially decided in favor of the plaintiff, but is currently being contested. On December 28, 1979, a Notice of Violation and Order to Take Corrective Action was served to the City by the Montana Department of Health and Environmental Sciences citing infraction of Rule 16-2.14(1) - S1480(1) of the Administrative Rules of Montana governing control of odors. This notice appears in Appendix 6 and mandates compliance deadlines for odor abatement.

It is noteworthy that the City of Kalispell, Montana, employed a similar Purifax sludge stabilization procedure utilizing a lagoon dewatering system. Very similar odor problems were encountered, and a decision was made in 1979 to change to a different stabilization technique. Municipal sludges exhibit enough site-specific variation to make parallels between the two situations impossible; however, the generation of offensive odors are common to both.

CHAPTER III

Recommendations

CHAPTER III
RECOMMENDATIONS

A. FUTURE SOLIDS FLOW AND LOAD FORECAST

As documented in the original Facilities Plan, wastewater flows in the planning area are anticipated to increase from the present level of 3.2 mgd to approximately 6 mgd. It is expected that sludge volumes will increase correspondingly; by the year 2000, daily sludge processed will approach 100,000 gpd. The solids content and other characteristics of the future sludge flow are very treatment-dependent; however, no radical changes in existing liquid treatment processes are anticipated. Thus the sludge stream should remain relatively constant.

The recommended addition of a new primary clarifier will have the greatest impact, improving solids capture and resulting in a possible solids concentration increase in the primary sludge due to elimination of the present primary facilities overload. This could have a minor impact on the secondary processes involving the ABF tower and aeration basin, but the net effect to secondary sludge production and/or character will be minimal. Addition of surface skimmers to the twin final clarifiers will capture additional floatable solids; however, the relative volume of this contribution would be insignificant. The addition of waste-activated (secondary) sludge dewatering equipment is a possibility in conjunction with revisions to the existing sludge handling system. Such a measure would obviously promote a significant rise in solids concentration and a corresponding decrease in total volume of waste-activated sludge to be ultimately stabilized.

Organic and chemical characteristics of the raw sludge stream generated including COD and nitrogen content will remain essentially unchanged. Heavy metals concentrations will likely remain unless future investigations reveal an industrial discharge that is in violation of pretreatment standards. In such an event, the party in violation could be legally constrained to implement on-site pretreatment for reduction of heavy metals in its wastewater discharges to the municipal system.

B. CONSTRAINTS TO SELECTION OF A SLUDGE HANDLING PLAN

Several important constraints must be recognized in the ultimate selection and recommendation of a sludge handling plan for the Helena Wastewater Treatment Plant. These are general fixed considerations that must be satisfied by the implementation of any selected plan in order to assure overall success. These can be categorized as follows:

i. Legal: The City is presently faced with a Notice of Violation of state law and a subsequent Order of Compliance. Obviously, satisfaction of these mandates is of primary and immediate significance. Strict deadlines must be met, and this could require the temporary adoption of an interim plan for solids management to afford time for implementation of permanent measures to serve

for the balance of the planning period. Any management plan, whether temporary or permanent, must comply with all local, state and federal regulations and programs applicable. Of particular significance are the Federal Clean Water Act (PL 92-500), the National Environmental Policy Act, the National Pollutant Discharge Elimination System program, and state air and water quality standards as administered by the Montana Department of Health and Environmental Sciences.

ii. Environmental Quality: As legally substantiated by many of the aforementioned regulations, any solids management plan implemented should provide adequate safeguards to the quality of the environment. Air quality must be maintained against the generation of both odors and other, less readily detectable contaminants. The quality of both surface waters and groundwater must be safeguarded. Soil conditions must not be adversely jeopardized. This is particularly critical in light of the widespread agriculture in the Helena Valley. The soils in the area are somewhat unique due to their high alkalinity and high cation exchange capacity, and any sludge disposal technique using the soil as a repository should be designed to be consistent with these parameters.

iii. Economics: A system to be adopted should be economically practical and consistent with available funding. It should reflect the least cost option of those considered that meet all other applicable constraints. This is to include capital as well as operation and maintenance and energy cost considerations. Additional revenue generating capability will be required of the City.

iv. Practicality: Ease of operation and system reliability are to be optimized. Recognition of operator capabilities and supportive services available must be made. Maintenance intensity is to be minimized.

Suggested alternatives can be evaluated for compliance with these criteria, and the optimal alternative can be selected.

C. ORIGINAL ALTERNATIVES

Contained in the original Facilities Plan were six alternatives for wastewater solids management. These are briefly summarized as follows:

<u>Alternative No. 1:</u> This alternative is basically a continuation of the existing sludge handling system utilizing the existing Purifax oxidation system in conjunction with lagoon dewatering and solids landfill. An additional Purifax unit would be required in 1985 to handle increased flows and provide backup capability.

<u>Alternative No. 2:</u> This alternative continues use of the Purifax system and provides for acquisition of an additional unit in 1985. During the summertime the sludge will be neutralized by additions of

lime and will be pumped through buried pipeline to an injection site assumed to be located on City-owned land within two miles of the treatment plant. At the injection site the sludge will travel through a flexible hose attached to an injector unit carried by a small crawler tractor which will incorporate it into the soil. In the winter when the injection site is frozen, the sludge will be held in lagoons at the plant site providing six months' storage until springtime when it will be neutralized by lime and pumped by dredge to the injection site. A building will be provided at the treatment plant to house lime storage and feed equipment and pumps.

Alternative No. 3: This alternative again retains the existing Purifax unit and adds a second unit in 1985. Sludge discharged from these units would be neutralized and conditioned with lime and polymer or ferric chloride. It would then be thickened by centrifugation and dewatered using a belt filter. Filtered solids would be hauled to a landfill in covered "dumpsters". A building would be provided to house the dewatering equipment and dumpsters, in addition to chemical storage and feed facilities.

Alternative No. 4: This alternative would discontinue use of the Purifax stabilization system. Two new high-rate primary digesters 50 feet in diameter with a 25-foot sidewall depth, and a digester control building would be added. The existing sludge holding tanks, assumed to be structurally adequate, would be fitted with gas holder covers and convereted to secondary digesters. Provisions for decanting from the secondary digesters would be added. Waste-activated sludge would be thickened by centrifuges from approximately 0.8 percent solids to about four percent solids prior to digestion. Centrifuges could be housed in the new digester building or in the existing Purifax building.

The digested sludge would be applied to land by subsurface injection as described in Alternative No. 2 except that chemical neutralization of the sludge would not be required.

Alternative No. 5: This alternative calls for anaerobic digestion of the sludge as in Alternative No.4. Instead of subsurface injection, this alternative calls for mechanical dewatering of the sludge and hauling to a landfill in dumpsters. A polymer feed system would be used to condition the sludge before it is applied to a belt filter press. As in Alternative No. 3, a building would be provided to house the dewatering equipment and dumpsters.

Alternative No. 6: This alternative would discontinue use of the Purifax unit and lagoons. Sludge would be treated with sufficient amounts of lime to raise the pH to 11.0 or more. This could be done in the existing sludge holding tanks. Treated sludge would be held for several hours to provide an effective stabilization. Sludge pumps would recirculate the tank contents to provide mixing. Waste-activated sludge would be thickened before the lime stabilization process by centrifuges from 0.8

percent solids to about four percent solids. After the high lime treatment, the sludge would be dewatered on belt presses as in Alternative No. 3. A building would be provided to house lime storage, lime feed equipment, dewatering equipment, and dumpsters which would be used to haul dewatered sludge to the landfill.

The cost comparison for these alternatives as contained in the original Facilities Plan is tabulated in Table 3. It is important to note that these costs as they appear are presented in 1978 dollars, and reflect capital and operational and maintenance costs for that year. Significant inflationary increases have occured since that time and invalidate these figures for the present year. The costs shown are representative for the purpose of comparison of these six alternatives to one another only.

Due to the recent draft publication of the *Comprehensive Solid Waste Management Plan for Southwest Montana Solid Waste Planning Area* (including the Helena Valley) authored by Barry Damschen of Robert Peccia & Associates in July, 1979, another alternative has come under consideration since publication of the original Facilities Plan. This alternative is summarized as follows:

Alternative No. 7: This alternative would utilize co-incineration of wastewater sludge with municipal refuse at a central energy recovery facility located at the Fort Harrison Veterans' Administration Hospital west of Helena. This alternative would be entirely contingent on construction at the hospital of the solid waste incineration facility which is only a possibility at this time. Wastewater sludge would be digested in single-stage, high-rate anaerobic digesters utilizing the existing sludge holding tanks. Waste-activated sludge would be centrifuged prior to digestion, and digested sludge would be dewatered on belt presses for truck transport to the co-incineration facility. At the hospital site, a rotary drier would further dry the sludge to powdered residue utilizing heat derived from excess steam generated by the incinerators. The dry sludge would then be fed to the incinerators in combination with municipal refuse.

These seven alternatives have been re-evaluated, and the recommendation has been made to continue Alternative No. 1 on an evaluative, short-term basis. An interim contingency plan has been developed and a replacement plan utilizing the process recommended in Alternative No. 4 with minor modifications has been recommended, should abandonment of the existing system become necessary. Alternative No. 7 has been developed in detail since it was not included in the original Facilities Plan.

D. RECOMMENDATIONS

1. General Recommendations

The results of this study justify the following recommendations regarding wastewater solids management practices at the Helena Treatment Plant:

i. Continue present operation of the existing Purifax and associated lagoons and landfill until it can be conclusively determined if improved operation and maintenance of the overall system is successful. This should become evident by July, 1980.

ii. Proceed immediately with implementation of the recommended interim sludge management plan. This is to include the acquisition of sludge injection equipment, operational capability for that equipment and the necessary permits and legal license for the emergency land injection of raw sludge. This practice is to be implemented in the immediate event of future odor problems.

iii. In or before July, 1980, the success of the improved operation of the Purifax system shall be evaluated and a final decision will be made as to its abandonment or continued use.

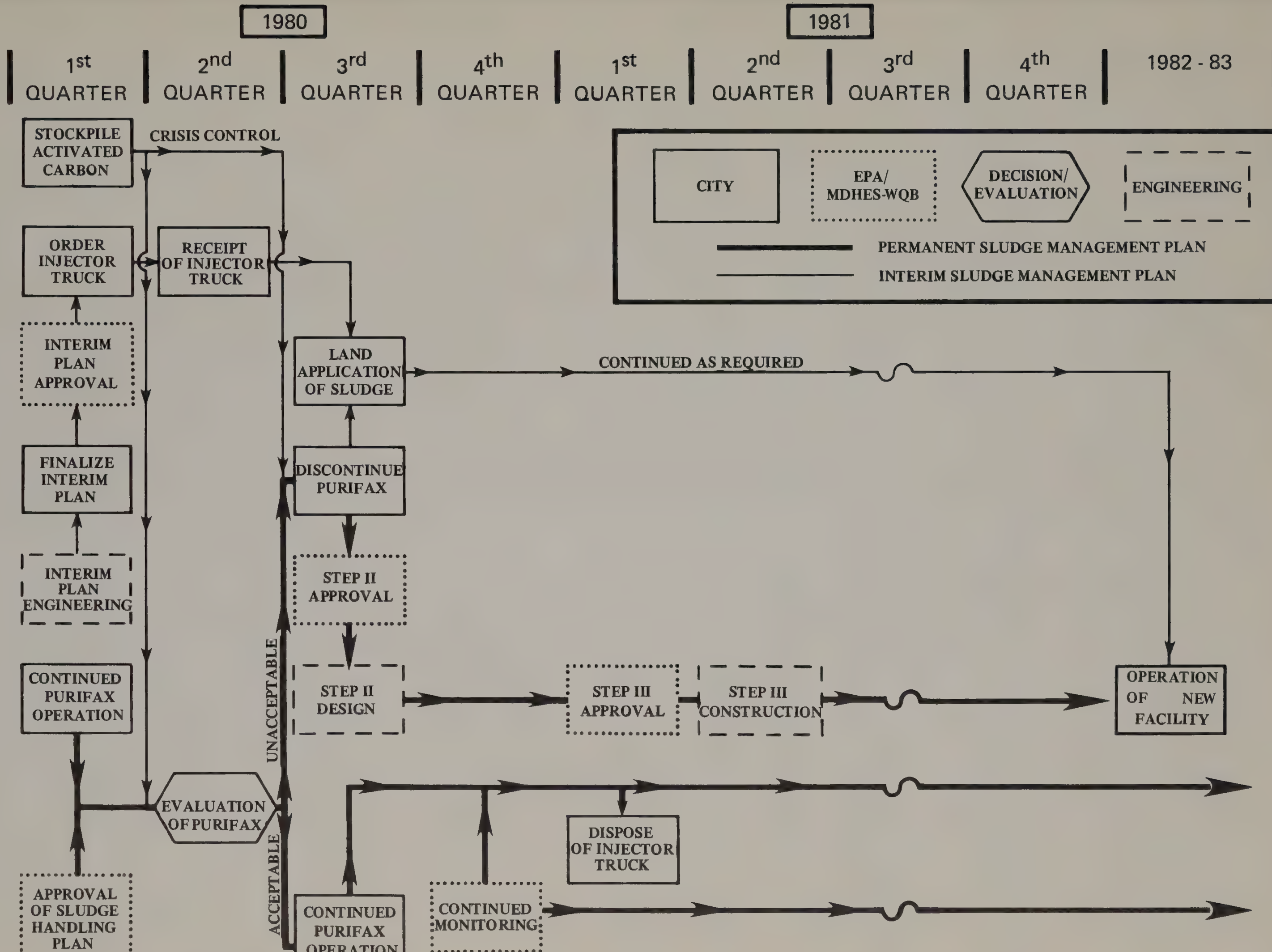
iv. Should abandonment of the Purifax system result, implementation of the recommended alternate permanent plan (a modification of Alternative No. 4) shall follow. This will involve design and construction of the necessary additional facilities.

This progression is outlined in Figure 4, and necessarily will require close scrutiny and frequent evaluation on the part of both the City and the Montana Department of Health and Environmental Sciences.

Excellent justification exists for these recommendations. The existing solids handling system, and in particular the Purifax unit and associated dewatering lagoons, have been plagued with maintenance and operational problems. Recognizing the capital investment involved in these facilities plus the recent significant expenditures for correction of operational problems, it is well warranted to allow an adequate opportunity to evaluate the success of the latest improvements. By virtue of the implementation of an interim plan on a standby basis, any resumption of the odor problems of the past will be remedied instantaneously. Should the existing system demonstrate failure on or before July, 1980, the interim plan allows innocuous sludge disposal until facilities required for the recommended plan can be constructed and put on line. Compliance with the recent Notice of Violation is afforded in any event.

2. Recommended Interim Plan

In view of the mandates of the Notice of Violation and Order to Take Corrective Action served to the City by the Montana Department of Health and Environmental Sciences, a guarantee is necessary that offensive odors will not be disseminated from the Helena Treatment Facility in the future. It is impossible to definitively determine at this time whether or not this will be the case. Indications of the analytical testing program employed in this study suggest a strong likelihood that



TENTATIVE SCHEDULE FOR INTERIM & PERMANENT SLUDGE MANAGEMENT PLANS

FIGURE 4

odors will continue to occur, although possibly at reduced or less offensive intensities. Future public input will ultimately have a decisive effect. Recognizing the investments in the present system and past operational problems, evidence is not conclusive enough to unequivocally disqualify the existing system from consideration. However, an interim plan is necessary to safeguard against future odor infractions if the existing system is to be continued. This interim plan includes the following provisions:

A mobile truck-type sludge injection vehicle with adequate on-board tankage would be immediately acquired. Such units are available from a number of manufacturers on a purchase, lease or lease/ purhcase basis. Manufacturers include:

Rickel Manufacturing Corporation, Salina, Kansas (4wd unit w/3,500 gal. tank @ $120,000)
Ag-Chem Equipment Company, Minneapolis, Minnesota (4wd unit w/3,800 gal. tank @ $105,000)
Big Wheels Company, Paxton, Illinois (2wd unit w/1,600 gal. tank @ $65,000)

An additional unit is available from the Briscoe Maphis Company (crawler tractor @ $90,000) but has no on-board tankage and requires the support services of a nurse tanker. Lease options available for any of these vehicles are prohibitively high for the short-term requirements of an interim contingency plan. Thus it is recommended that the City proceed with purchase of one of the machines; high resale value can be anticipated, and net costs would be minimized.

Such a vehicle would be directly usable as part of the recommended alternate permanent plan (a modified version of Alternative No. 4), and if the Purifax system were to be abandoned, the vehicle would be retained. Should the Purifax system be retained indefinitely under the present operational mode, the injection vehicle would be retained as a backup.

A suitable loading port for the injection vehicle would be immediately constructed at the existing Sludge Oxidation Building along the influent piping for the raw sludge. This would enable direct vehicle hookup to take on raw sludge, should the interim plan be put into service. Raw sludge could then be transported by the vehicle to the 40-acre City-owned plot currently utilized for dried solids landfilling operations. Here sludge would be injected into the soil at a depth of six to twelve inches during frost-free months. Once adequate frost buildup in the ground occured, the sludge could be either surface-applied, utilizing the usual low-level spray equipment that comes with injector vehicles, or routed through the Purifax system for treatment and discharged to the existing lagoons. The surface application option would be the most desirable since the spring thawing of Purifaxed sludge in the lagoons would likely cause some additional odor problems. The Montana Water Quality Bureau has tentatively indicated a willingness to further consider the winter spray option. Odor problems are

nonexistent with injection due to the earth cover afforded. Winter spraying would minimize odor creation through instantaneous freeze-up of the sludge spray, and/or expedient adsorption onto vegetative stubble of the ground surface. A further precaution can be provided by a spring injector application over a winter spray site which works the soil to promote incorporation of the previous surface application.

Should the winter spray application of raw sludge on an interim basis prove unfeasible, the existing Purifax system and drying lagoons could alternatively be used. During the months of prolonged freezing temperatures the odor nuisance is drastically reduced. Lagoon contents are quickly frozen, and few odor complaints have been received. Offensive odors are generally restricted to midwinter thaw periods when the surface layer of filled cells tends to temporarily liquify. By using the Purifax system only during the winter months, a much lower volume of sludge would need to be dewatered in the existing lagoons, approximately four months' accumulation in lieu of the usual twelve month load. Thus the depth of application could be held to less than one foot, and dewatering in the spring would be much more expedient. Odors would be of a much shorter duration, and if severe could be controlled with activated carbon applications as discussed on the following page.

With the injection or land application of raw sludge, public access to the site utilized is required to be closed, and runoff of surface water is to be minimized. Thus the flat and remote, access-restricted 40-acre parcel suggested would be ideal. This site is described in detail in the following section (p. 36). The available 40 acres would withstand application for approximately two years based on cadmium-loading criteria, which is well in excess of the time for which the interim plan would be employed.

Sludge could be applied at a rate of up to 500,000 gallons per acre per year with the total cumulative application not to exceed 2,500,000 gallons per acre. These application rates are only tentative and would require refinement and approval from the State.

The present daily sludge flow would require approximately 14 trips per day to and from the interim injection site by the vehicle, if equipped with a 3,500 gallon tank. Cycle time for such a vehicle to fill, travel one-quarter mile to the site, inject and return would be approximately one-half hour. Thus eight-hour per day, six-day per week operation would probably be necessary. Manpower at the treatment plant would need to be increased by one or two man/shifts.

Approval of such interim application of raw sludge would be necessary from the State, and this permission should be requested immediately on a standby basis. Once such license was obtained and the necessary capital was available, the City would be prepared to immediately activate the contingency plan, should problems be encountered with the Purifax system.

Recognizing the time required for such approval and obtaining equipment, a formal request should be made immediately and procural of the required capital should begin. Similar permission was granted to the City of Kalispell, and with adequate safeguards the State would be likely to respond favorably.

An additional measure required as part of the interim plan is the remedial capability to correct an odor problem should it occur in a lagoon cell(s) as the Purifax system continues to operate. This is to be afforded by the immediate acquisition of an adequate stockpile of powdered activated carbon that could be applied to the lagoon surface to absorb odors in a critical situation. Powdered activated carbon is presently used at the Helena Municipal Water Treatment Plant, and arrangements for the necessary transfer of some surplus material could be made. Alternatively, the carbon could be purchased and delivered to the Wastewater Treatment Plant from Dyce Sales and Engineering in Billings, Montana, or another suitable supplier.

The anticipated implementation costs for the interim sludge handling plan are projected in Table 4. It is impossible to predict how long, if at all, the program would be operated; however, a first-year cost has been projected assuming nine months of actual operation of the injection vehicle.

TABLE 4

FIRST YEAR COST SUMMARY

IMPLEMENTATION COST OF STANDBY INTERIM SLUDGE HANDLING PLAN †

Description	First Year Cost
Activated Carbon, 30,000 lb. stockpile @ $.25/lb. (Could deodorize two lagoon cells in event of a crisis)	$7,500
Mobile Sludge Injection Vehicle**	120,000
Installation of Temporary Injector Vehicle Loading Port at Sludge Oxidation Building	1,500
Engineering, Legal & Administrative Fees associated with temporary land application system implementation	5,000
FIRST YEAR CAPITAL COST	$134,000
Operation and Maintenance*	
Labor (1.5 man/shifts for 9 months)	$22,200
Vehicle Fuel, O & M (1,875 hrs. @ $6.50/hr.)	12,200
First Year O & M Cost	$34,400
TOTAL FIRST YEAR COST	$168,400

† Costs shown for first year operation of the proposed standby interim sludge handling plan are only approximate. They depend to a large extent on the resale opportunities and price obtainable for the used mobile sludge injection vehicle if it were to no longer be used. Capital costs of such equipment are also subject to wide variations, depending on the exact type of vehicle desired. First year costs presented would decline significantly in subsequent years, if the interim plan were to be continued.

**Cost shown is the delivered price for the vehicle. No allowance for resale or remaining value has been included. Due to the interim nature of the program under which this vehicle would be used, its purchase price is not eligible directly for funding assistance under the EPA Construction Grants Program.

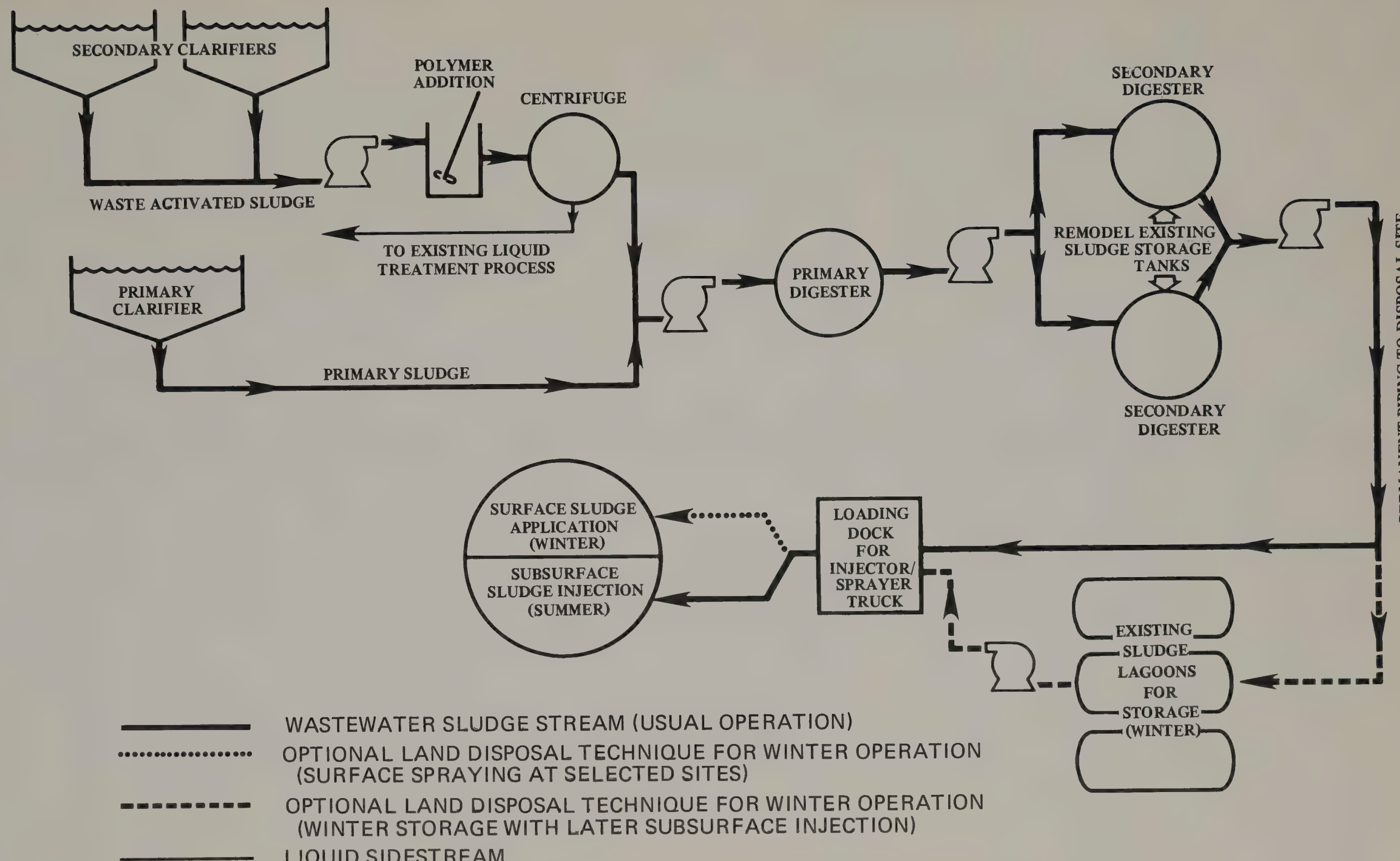
* A very conservative allowance of nine months of full operation of the injector vehicle during the first year was made. Thus costs shown for O & M are the maximum possible during that year.

These interim measures are the optimum of those available. Capital investment is minimized, and the major equipment involved quite possibly would find future application on a permanent basis. These measures offer good flexibility, and are reliable and straightforward. The environmental impact of operation of such a program of raw sludge injection is documented elsewhere (see page 41). As long as well-founded application rates are utilized, the process differs little in impact from the injection of a stabilized sludge. Bacterial decay is induced in the soil, and the essential difference is that the stabilization occurs there instead of earlier. The presence of virulent pathogens in the raw sludge is the most obvious hazard, but the prohibition of public access affords a reasonable safeguard.

3. Recommended Alternate Permanent Plan

The permanent wastewater solids management plan recommended as an alternative to continue operation of the Purifax system is Alternative No. 4 as presented in the original Facilities Plan. If the existing solids handling system is necessarily abandoned after the evaluation period, this alternative utilizing anaerobic digestion followed by sludge injection represents the overall most attractive replacement option. As cited in the original plan, a comparative composite ranking of the alternatives considered rated Alternative No. 1 first, with Alternatives No. 2 and 4 receiving equivalent ratings of second (ref. Table 14, "Ranking of Alternatives" in original plan, p. VI-13). Other alternatives all received lesser ratings. The conclusion of this investigation and the associated results of the analytical testing program strongly substantiated this conclusion. Discussions with Water Quality Bureau personnel indicated a dissatisfaction with the prospect of injecting Purifaxed sludge into the soil after pH adjustment (Alternative No. 2) due to the questionable effect on subsequent agricultural land use and the possibility of widespread application of a waste material containing certain compounds whose toxicological properties are indeterminate at this time. In view of the results of analytical tests performed serious questions are raised in this regard, and Alternative No. 2 was thus withdrawn from consideration. Although high capital costs are associated with Alternative No. 4, these are largely offset by reduced operation and maintenance costs and the opportunities for energy conservation implicit in the process. Additional investigation afforded a significant reduction in capital expenditures necesssary to implement this alternative by replacement of the proposed two new primary anaerobic digesters with a single unit.

A schematic of the solids handling process recommended for anaerobic digestion and sludge injection is shown in Figure 5. Revisions to the existing Sludgd Oxidation Building would allow the installation of new twin 80-gpm centrifuges to dewater the waste-activated (secondary) sludge to a solids concentration amenable to anaerobic digester feed, four to five percent. Polymer introduction prior to centrifuging would be required to assure performance, and the necessary polymer feed equipment would also be housed in this building. Anaerobic digestion would be high-rate, two-stage. One new 530,000 gallon primary digester would be constructed on open ground in the northwest portion of the facility grounds, and would be 60 feet in diameter by 25 feet SWD. This would be maintained at relatively constant levels in the process and thoroughly mixed to optimize methane



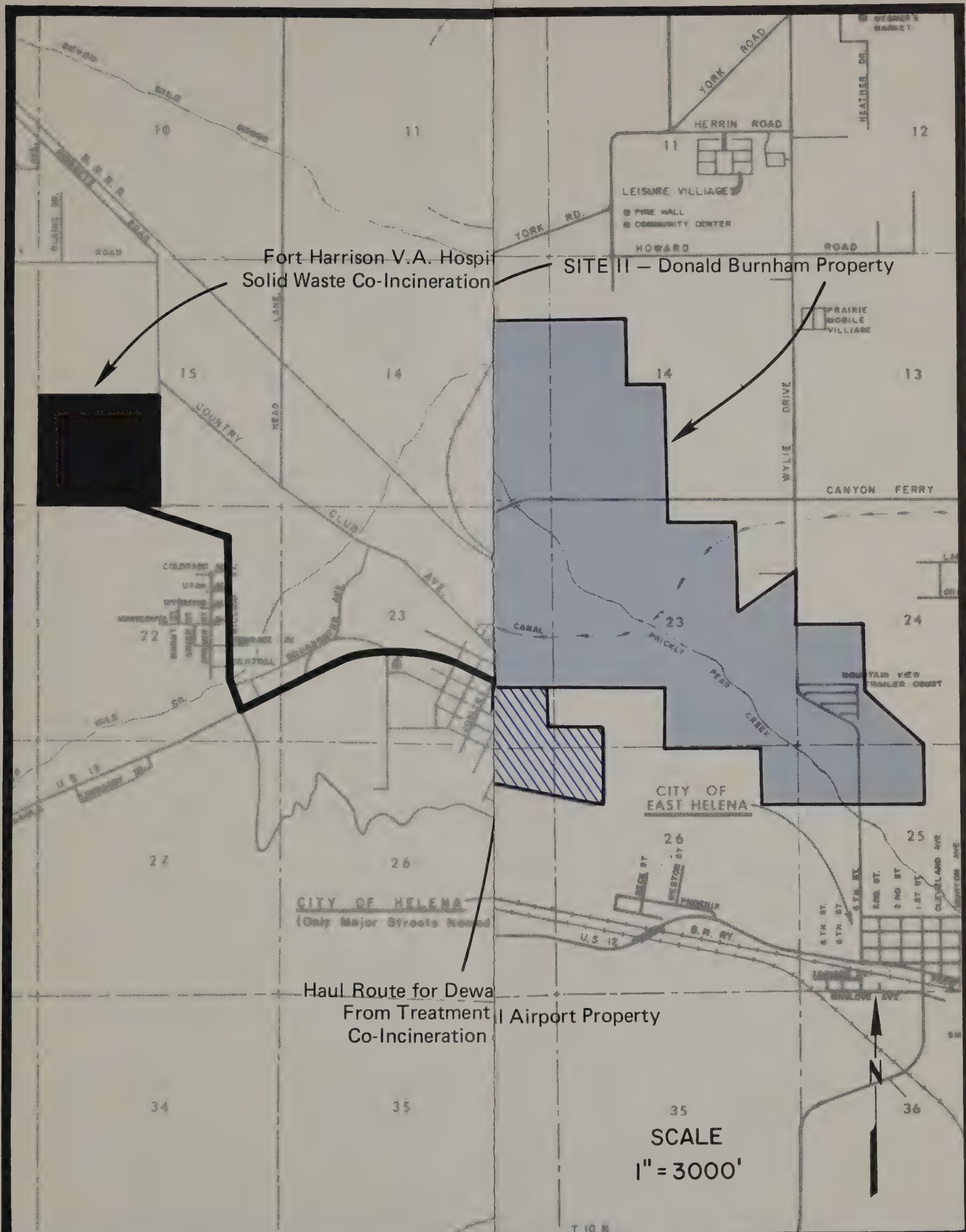
ANAEROBIC DIGESTION & LAND APPLICATION ALTERNATIVE (schematic)

FIGURE 5

production and sludge stabilization. Primary digester effluent would be routed to twin secondary digesters made from the existing sludge storage tanks which originally served as low-rate anaerobic digesters at the time of plant construction. These secondaries, equipped with floating covers, would allow storage capacity for both digested sludge and methane gas, and their levels would fluctuate as required. Methane generated in the system would be used for heating of the primary digesters where the majority of the digestive process would occur. Any surplus could be employed for plant utility requirements; however, no allowance has been made for this due to the uncertainty of the generation of a surplus. The secondary digesters would have no mixing or supplemental heating, and would promote settling of the digester solids allowing decanting of supernatent liquid to be returned to the existing liquid treatment process. This creates some additional organic loading on the liquid process; however, with implementation of the recommended improvements in the liquid process, supernatent return would be a practical possibility. It would have the positive benefit of reducing the volume of sludge to be subsequently handled by mobile injection equipment.

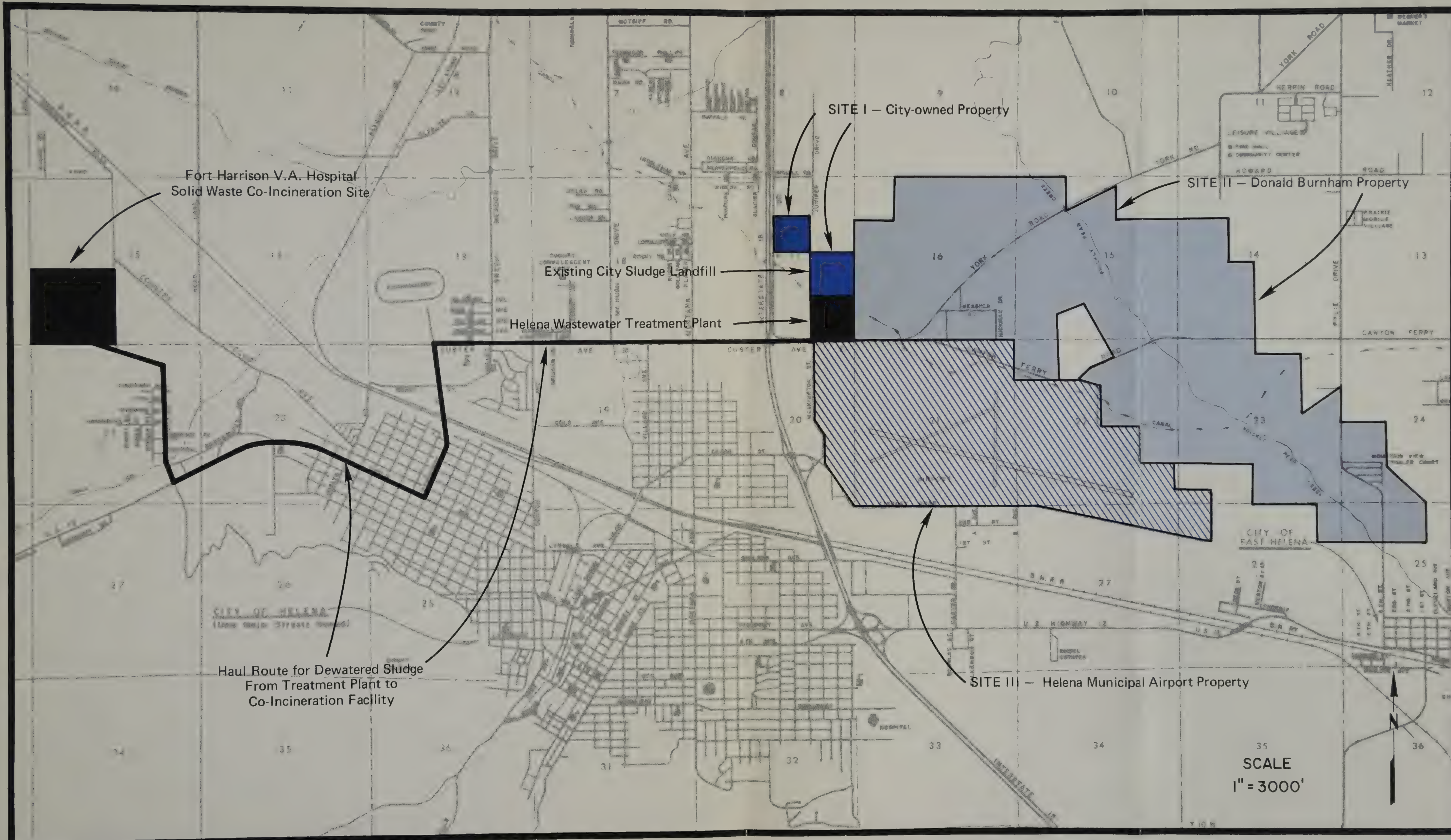
Piping and pumping flexibility would be provided in the system to allow the routing of raw sludge directly to either of the primary digesters and from there to either of the secondaries. The system would necessarily involve some major revisions and additions to the existing piping system at the plant, although existing piping to the sludge holding tanks and the Sludge Oxidation Building could be partially utilized. Additional sludge pumps would also be required in addition to the reapplication of some of the existing units.

From the secondary digesters, stabilized sludge would be pumped through a new sludge transfer line to a land application site for injection or surface application. Three potential sites in close proximity to the plant have been investigated, and tentative indications have been given by the owners that they would favorably consider such a program. These sites include: Site I - usable portions of two 40-acre plots owned by the City directly north of the plant, one of which is presently used for dried sludge landfilling; Site II - farmland directly east of the plant owned by Donald Burham; and Site III - Helena Municipal Airport property. These sites are shown in Figure 6, and relevant details are summarized in Table 5 . The site life projected for Site I based on cadmium loading criteria is relatively short (Table 5). It is thus necessary to consider Sites II or III for use to meet needs throughout the planning period. Both have relative benefits. Land use is more constant at the airport site, and can be safely presumed to remain so indefinitely. However, any nuisance afforded by the injection process could be in direct conflict with public interests. The Burnham property affords a degree of privacy and is slightly closer to the plant. However, sludge application would have to be more intensively controlled to remain compatible with the owner's agricultural interests. Water table depths are adequate at both locations, and the prevailing soil characteristics of both are likewise amenable to a sludge application system.



WAS IATIVES

FIGURE 6



WASTEWATER SLUDGE DISPOSAL SITE ALTERNATIVES

FIGURE 6

TABLE 5

WASTEWATER SLUDGE DISPOSAL SITES

(Also See Figure 6)

Site No.	Site Ownership	Approx. Ac. Available †	Projected Site Life*	Soil Characteristics	pH Tendencies	Depth to Groundwater
I	City of Helena	80	4½ yrs.	Mixed cobbly & stony clay loam; usually deep (over 36") w/layers of coarse sands & gravels in the subsoil; northwest 40 acre plot substantially more gravelly; occuring on gently sloping benchlands.	Alkaline (8.0 to 8.5)	12 to 15+ feet
II	Donald Burnham	2,000	135 yrs.	Well-drained clay loam predominating on benchlands (sec. 16); slowly draining silt loam w/moderate salt condition predominates along Prickly Pear Creek corridor (sec. 15); well-drained alluvial loams predominate elsewhere; soil depth varies from 24" to 60"+; subsoil contains layers of loamy sands, sand & gravels; occuring on benchlands & nearly level stream terraces.	Alkaline (8.0 to 8.5)	Averages less than 6' in immediate corridor of Prickly Pear Creek & irrigation ditches (subject to extreme seasonal fluctuation); 12'+ elsewhere
III	Municipal Airport	900	60 yrs.	Mixed cobbly & stony clay loam; usually deep (over 36") w/layers of coarse sands in the subsoil; occuring on level to nearly level benchlands.	Alkaline (8.0 to 8.5)	12'+ except in immediate corridor of irrigation canal

*Based on cumulative cadmium loading at site as per EPA guidelines (ref. Fed. Reg. 44:179, September 13, 1979). Rotation of plots within a site would be necessary to comply with annual loading criteria. Projections are based on existing sludge generation rate and have not been adjusted for future increases in waste flows.

† These acreages represent the total approximate land in the present owner's domain. Obviously, the total amount shown is not available for land application of sludge. The most appropriate and acceptable plots contained therein would necessarily have to be determined and negotiated with the owners on an individual basis.

The land application of anaerobically digested sludge legally restricts certain future use. The following requirements must be met (ref. Federal Register 44:179, September 13, 1979):

i. If crops are grown for direct human consumption within 18 months of the sludge application, no contact is allowable between the sludge and edible portions of the crop. If this cannot be guaranteed, such crops cannot be grown for 18 months after application.

ii. Grazing by animals whose products are consumed by humans must be prevented for at least a month after sludge application.

iii. Public access to the application facility must be controlled for at least 12 months.

Thus consultation between the City and the owners of Sites II and III are advised before a final selection would be made.

The operational mode of the sludge land application would be similar to that described in conjunction with the Recommended Interim Plan (preceding). Direct injection using an injector vehicle would be utilized during frost-free months. This vehicle would be serviced by a loading port at the end of the sludge transfer line, greatly reducing vehicle cycle time. During winter months surface application using a spray bar on the same vehicle would be employed, if possible. Again, control of runoff and public nuisance during winter operation would be minimized by the presence of vegetative stubble on the site and working of the soil immediately after the spring thaw. An alternative for winter operation would utilize two of the existing lagoon cells for cold weather storage. Minor modifications would be necessary to afford this capability, and would involve dredging to increase storage depth while holding exposed surface area to a minimum. The latter consideration is in anticipation of offensive odors associated with the spring thaw of the lagoon contents. If such a problem proved severe, covers would have to be added to the cells. However, no allowance has been made for this addition at this time; rather, winter spray application of the sludge should be pursued initially as the preferred alternative.

During either the summer or winter operation of a land application system, the following tentative loading rates based on sludge cadmium content and ambient soil conditions have been established and were used to estimate the useful lives of the sites under consideration: (requirements change with time in compliance with the EPA National Pollutant Discharge Elimination System Program)

Annual Load (through June, 1984): 500,000 gal/ac
Annual Load (July, 1984 through 1986): 300,000 gal/ac
Annual Load (1987 and thereafter): 125,000 gal/ac
TOTAL CUMULATIVE LOAD: 2,500,000 gal/ac

Thus any one acre can be reused year after year, provided annual loads are not exceeded, until the total cumulative loading has been reached. Thus precise scheduling and recording of sludge applications is essential to the proper operation of such a program.

Capital costs of the entire digestion/injection alternative are presented in Table 6. Annual costs are then summarized in Table 7. Investigation of the costs reported for this alternative in the original Facilities Plan as compared with costs developed for this study revealed a discrepancy greater than could be accounted for by inflationary increases alone. However, cost verifications obtained from equipment manufacturers and recent construction bids in the area showed the original cost reported for the new primary anaerobic digesters to be approximately 35 percent too low, despite a realistic inflation allowance. This cost has been revised to reflect the increase, along with some minor adjustments to other line items. This was also directly reflected in several annual cost items.

4. Development of Alternative No. 7 - Municipal Solid Waste/Wastewater Sludge Co-Incineration

An additional wastewater solids handling alternative has evolved in conjunction with an option presented in the *Comprehensive Solid Waste Management Plan for Southwest Montana Solid Waste Planning Area (Draft Report, July, 1979)* prepared by Robert Peccia and Associates. This alternative, employing co-incineration of dried sludge with municipal refuse for energy recovery, affords an integrated approach to solid waste management in the Helena Valley area.

A feasibility analysis for energy-derived materials from municipal solid waste contained in the draft report explored the possibility of a central solid waste energy recovery facility to handle municipal solid waste from the Helena area. This facility would be operated in place of the present City solid waste landfill, and revenue would be generated through sale of the derived energy. Local energy markets were investigated, and the existing Fort Harrison Veterans' Administration Hospital located west of Helena was recommended as a site for such a facility (see Figure 6, preceding). For details of the proposed system and associated analysis, the reader is referred to the draft report cited above; only a brief recap of the system will be included here.

Solid waste would be trucked to the site in conventional collection vehicles, deposited on a tipping floor from which a front-end loader would transfer it to a conveyor system feeding two modular 50-ton-per-day Consumat incinerators. These units, equipped with heat exchangers for steam generation, employ a limited amount of supplementary fuel and have provisions for recombustion of their own stack gases to eliminate air particulate emissions. Thus no additional stack gas cleanup is required before discharge. An annual average of one-third of the steam generated would be used for heating of the hospital facilities in lieu of the steam heat presently generated by natural gas-fired boilers. The remaining steam would be routed through an extraction turbine and generator, with

TABLE 6

CAPITAL COST SUMMARY*
ANAEROBIC DIGESTION/SLUDGE INJECTION ALTERNATIVE

Item	Capital Cost	Annual Amortization
Waste-Activated Sludge Dewatering Equipment		
Polymer Feed Equipment	$15,600	
Centrifuges (two @ 80 gpm each)	210,000	
Modifications to Existing Sludge Oxidation Bldg.	15,000	
Subtotal —	240,600	
Amortization @ 7 1/8% for 20 years		$22,900
Anaerobic Digesters		
New Primary Digester (60′ dia. x 25′ SWD)	$800,000	
Convert Two Holding Tanks to Secondary Digesters	300,000	
Subtotal —	1,100,000	
Amortization @7 1/8% for 20 years		$104,800
Revision of Existing Lagoons for Standby Sludge Storage	$10,000	
Amortization @7 1/8% for 20 years		$1,000
Pipelines and Pumps	$110,000	
Amortization @ 7 1/8% for 20 years		$10,500
Sludge Injection System		
Sludge Transfer Pipeline with Pumps & Loading Port	$275,000	
Mobile Sludge Injection Vehicle	121,000	
Site Preparation and Erosion Control	20,000	
Subtotal —	416,000	
Amortization @ 7 1/8% for 20 years (7 1/8% for 10 years for injection vehicle)		$45,400
TOTAL CONSTRUCTION COST	$1,876,600	$184,600
Engineering, Legal & Administrative (15%)	281,500	27,700
Contingency (10%)	187,700	18,500
TOTAL COST—	$2,345,800	$230,800

*Costs presented are based on anticipated 1980 construction costs in 1980 dollars. It is assumed that the majority of construction would occur sometime thereafter, and an inflation allowance of 13% per year should be added.

TABLE 7

ANNUAL COST SUMMARY*
ANAEROBIC DIGESTION/SLUDGE INJECTION ALTERNATIVE

Item	Annual Cost
Labor (Including benefits @ 30%)	
One laborer for sludge dewatering	$18,200
One operator for sludge injection vehicle	22,800
Operation and Maintenance (Including power consumption)	
Dewatering chemicals (polymer @ $10/ton dry solids)	5,500
Waste-activated sludge dewatering equipment (5% of capital)	12,000
Anaerobic digestions (1% of capital)	11,000
Sludge injection vehicle (8 hrs./day @ $6.50/hr. 6 days/week)	16,200
Injection site maintenance and erosion control	3,000
Pumping Costs and Pipeline Maintenance, Including Sludge Transfer Line (5 % of Capital)	19,300
Subtotal –	$108,000
Amortization of Capital	230,800
TOTAL ANNUAL COST–	$338,800

*Costs are presented in 1980 dollars.

the resulting electrical power to be used on-site or sold back into the local Montana Power Company grid. Annual costs for the Fort Harrison facility are shown in Table 8. Significant costs are associated with the increased transportation distance to the facility as compared with the existing City landfill. The annual cost overview presented shows that a net system cost would be incurred by operating the facility of approximately $200,000 per year. This is a cost in addition to present landfill costs, which have been accounted as a facility revenue in the table.

The amenability of the modular incinerators proposed at Fort Harrison to the co-incineration of wastewater sludge in conjunction with the municipal solid waste feed has been demonstrated as practical, provided water introduced in combination with sludge solids does not impede combustion. This enables development of a process by which sludge disposal activities could be conveniently combined into the operation of the Fort Harrison facility. This process is shown in schematic in Figure 7, and has a number of initial steps in common with the recommended permanent wastewater solids management plan presented in the preceding section. Waste-activated sludge would be dosed with polymer and centrifuged to a solids concentration of four to five percent in preparation for subsequent anaerobic digestion. A new building would be constructed to house the waste-activated sludge dewatering equipment. Remodeling of the existing sludge holding tanks would create two single-stage, high-rate anaerobic digesters to receive the combined primary and thickened secondary sludge stream. These digesters would be operated at a significantly lower solids retention time than that obtained through the two-stage digestion process recounted previously. However, the lesser degree of stabilization accomplished will be adequate for subsequent belt filter dewatering operations. Two 80-gpm belt filters will be housed in the existing Sludge Oxidation Building; polymer feed equipment will also be included to promote filter operation. It is anticipated that a sludge cake of approximately 20 percent solids will be obtained which would be amenable to handling and daily truck transport to the Fort Harrison incineration facility. Approximately 25 cubic yards of 20 percent cake would be produced per day at present plant flows; this figure would roughly double by the year 2000. One trip per day from the treatment plant to Fort Harrison would be necessary at a haul distance of seven miles one way (see Figure 6, preceding). The truck would dump the sludge cake into a receiving pit served by a belt conveyor which would transport the material to a steel bin with four days of storage capacity at the present rate of sludge production. An auger feed system would transfer bin contents to a direct rotary sludge drier to be equipped with a heat exchanger to enable use of incinerator process steam as fuel. The dried sludge would be augered into individual feeders added to the two incinerators. These mechanical feeders would control dried sludge feed to the incoming municipal refuse en route to the combustion chamber.

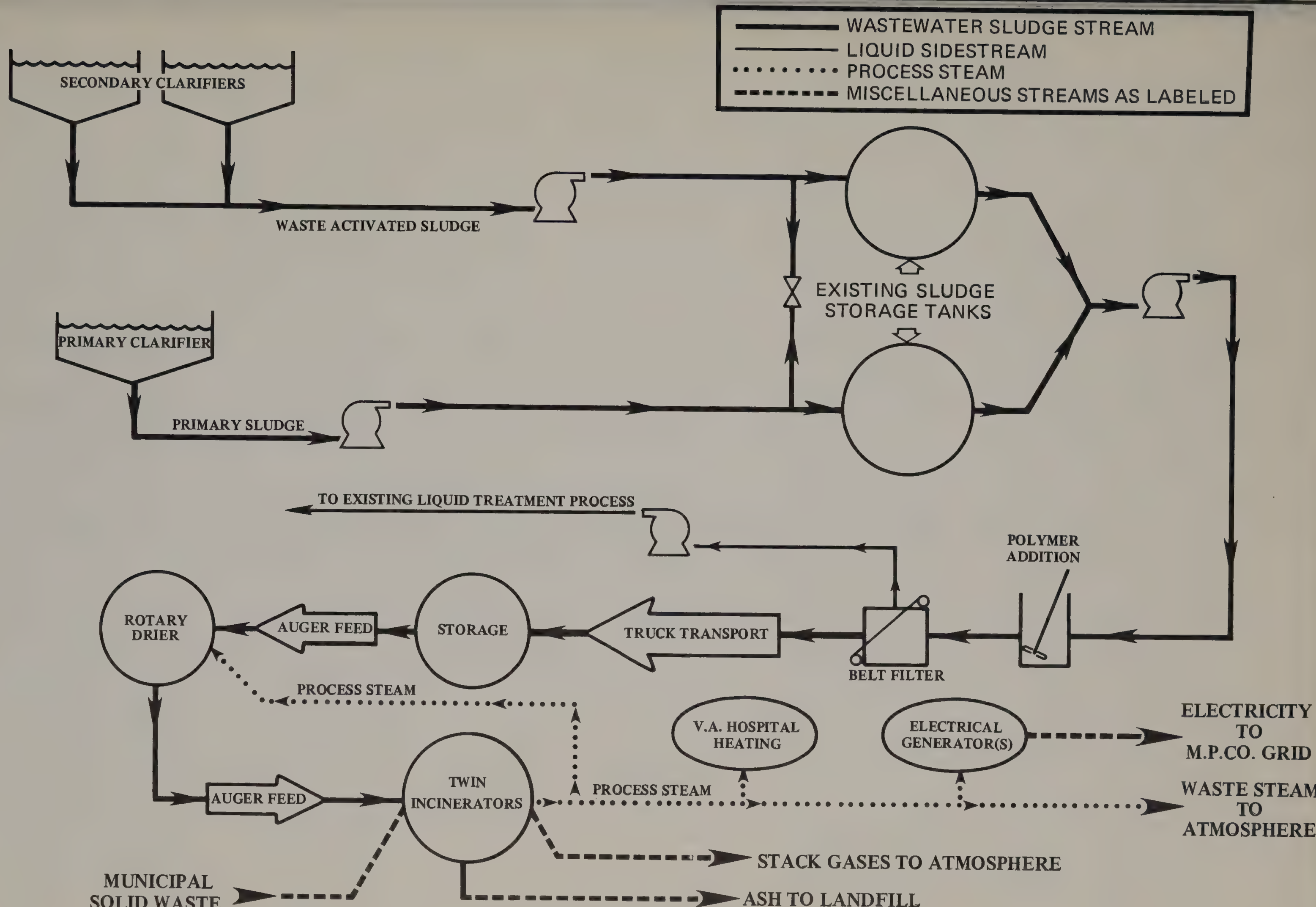
The high ratio of sludge volume to municipal refuse generated in the Helena area precluded the possibility of effective combustion of the mixture without sludge drying in addition to dewatering.

TABLE 8

FORT HARRISON SOLID WASTE FACILITY ANNUAL COSTS

Description	Annual Cost
Facility Cost (Total Capital @ $2,855,000)	$305,000
Labor	315,000
Equipment Operation and Maintenance	150,000
Utilities and Fuel Gas for Incinerators	50,000
Power Generation (Turbine Maintenance)	24,000
Ash Landfill (Class III)	48,000
Insurance	12,000
Increased Transportation Cost	52,000
TOTAL COST–	$956,000
Less Facility Revenues (Including Steam & Electrical Sales)	871,000
NET SYSTEM COST–	$85,000

*(Ref. 1979 SW Mont. Solid Waste Management Plan Draft Report prepared by Robert Peccia & Associates). Costs presented are for municipal solid waste incineration alone with energy recovery. Additional costs associated with sludge co-incineration are reported in Table 9 . All costs are presented in 1980 dollars.



MUNICIPAL SOLID WASTE/WASTEWATER SLUDGE CO-INCINERATION ALTERNATIVE

FIGURE 7

Due to the fortuitous availability of surplus process steam at the Fort Harrison facility, the economics of the drying operation are surprisingly attractive. No significant fuel cost is incurred due to the steam surplus. An annual average surplus of approximately two-thirds of the steam produced at the site would otherwise be diverted to electrical generation. However, this turbine process is a cost-intensive one, such that electrical sales, once adjusted for expenses involved in generation, amount to only 12 percent of the facility revenues reported in Table 8. The steam requirements diverted to the sludge drying operation would reduce electrical revenues by only 13 percent or approximately $14,000 (Table 11).

Capital costs for the additional facilities required for co-incineration of sludge are presented in Table 9. These do not reflect the cost of the incinerator system required for straight municipal refuse combustion, only the additions required to handle the added sludge. At the present rate of sludge generation, dried solids from the sludge stream constitute an additional tonnage loading on the incinerator system of only three percent. No cost has been assessed for this relatively insignificant increment.

Annual costs for the co-incineration alternative are compiled in Table 10. These again are presented from the standpoint of additions to the base municipal refuse incineration system. It has been assumed that operating expenses of the base municipal system would remain, irrespective of the introduction of dried sludge into the process steam.

An interesting comparison of net cost for this wastewater solids management alternative is possible with that of the recommended alternative permanent plan (Table 11). Taken individually on the annual cost bases presented (Tables 7 and 10), a direct comparison of the two alternatives is not possible. This is due to the fact that the municipal refuse incineration facility is projected to operate at a deficit of $85,000 per year (Table 8); this loss must be assessed against Alternative No. 7 to afford a valid comparison on an annual cost basis with the modified Alternative No. 4. This affords a projected margin of economic superiority of the recommende digest/inject alternative of $18,200 per year. This margin could diminish during the course of the planning period due to continued increases in energy costs. Higher prices for natural gas and electricity would push the Fort Harrison facility closer to a break-even operation from a municipal refuse standpoint.

Despite such possibilities, the sludge management alternative of co-incineration for Helena poses some serious problems. First and foremost, the alternative is precluded from practical consideration at this time due to the very tentative planning stage of the Fort Harrison facility. Implementation of such a system is at best five years down the road. Should the Purifax system be retained due to demonstrated performance improvements, it would be worthwhile to re-evaluate the feasibility of the co-incieration alternative in 1985 before a recommended additional Purifax unit was acquired. However,

TABLE 9

CAPITAL COST SUMMARY*
MUNICIPAL SOLID WASTE/WASTEWATER SLUDGE CO–INCINERATION ALTERNATIVE

Item	Capital Cost	Annual Amortization
Sludge Dewatering Equipment		
Polymer Feed Equipment	$18,800	
Belt Presses (two @ 80 gpm each)	240,000	
Modifications to Existing Sludge Oxidation Building (including truck loading conveyor)	25,000	
Subtotal –	$283,800	
Amortization @ 7 1/8% for 20 years)		$27,000
Pipelines and Pumps		
(including Holding Tank Recirculation Pumps)	$80,000	
Amortization @ 7 1/8% for 20 years)		$7,600
Truck Transport		
Semi-Tractor	$50,000	
Covered Hopper Trailer (75 cu. yd.)	28,000	
Subtotal –	$78,000	
Amortization @ 7 1/8% for 10 years		$11,200
Additional Facilities at Fort Harrison Co-Incineration Site		
Steel Storage Bin (100 cu. yd.) with truck unloading conveyor	$40,000	
Auger Feed System from Storage Bin to Drier	15,000	
Rotary Drier with Heat Exchanger (to utilize process steam)	175,000	
Auger Feed System from Drier to Incineration Feeders	45,000	
Modifications to Incinerators (including two individual dried sludge feeders)	30,000	
Increased Building Space (6000 sq. ft. @ $25/sq. ft)	150,000	
Subtotal –	$455,000	
Amortization @ 7 1/8% for 15 years (7 1/8% for 20 years for building space)		$48,000

*Costs presented are based on anticipated 1980 construction costs in 1980 dollars. It is assumed that the majority of construction would occur sometime thereafter, and an inflation allowance of 13% per year should be added.

TABLE 9
(Cont.)

CAPITAL COST SUMMARY*
MUNICIPAL SOLID WASTE/WASTEWATER SLUDGE CO–INCINERATION ALTERNATIVE

TOTAL CONSTRUCTION COST	$896,800	$93,800
Engineering, Legal & Administrative Fees (15%)	134,500	14,100
Contingency (10%)	89,700	9,400
TOTAL COST –	$1,121,000	$117,300

TABLE 10

ANNUAL COST SUMMARY*

MUNICIPAL SOLID WASTE/WASTEWATER SLUDGE CO-INCINERATION ALTERNATIVE

Item	Annual Cost
Labor (Including benefits @ 30%)	
One laborer for sludge dewatering	$ 18,200
One truck driver (½ time)	11,400
Operation and Maintenance (Including power consumption)	
Dewatering chemicals (polymer @ $30/ton dry solids)	32,900
Sludge dewatering equipment (5% of capital)	14,200
Facilities at Fort Harrison Co-Incineration Site (10% of capital)	45,500
Pumping Costs and Pipeline Maintenance (10% of capital)	8,000
Truck Transportation (15 miles/day @ $1/mile)	5,500
Insurance	5,000
Subtotal —	$140,700
Amortization of Capital	117,300
TOTAL ANNUAL COST	$258,000

*Costs are presented in 1980 dollars.

TABLE 11

COMBINED ANNUAL COST SUMMARY*
MUNICIPAL SOLID WASTE & WASTEWATER SLUDGE DISPOSAL

Item	Annual Cost
Wastewater Treatment Plant Facilities	
Labor	$ 29,600
Operation & Maintenance	92,600
Pumping Costs	8,000
Truck Transportation Costs	5,500
Insurance	5,000
Amortization	117,300
Subtotal –	$258,000
Fort Harrison Facility Total Annual Cost	$956,000
Steam for Sludge Drying (Lost Electrical Sales)	14,000
TOTAL COST –	$1,228,000
Less Fort Harrison Facility Revenues (including steam & electrical sales)	871,000
Less Cost of Comparable Sludge Handling System (Alternative No. 7)	338,800
TOTAL REVENUE –	$1,209,800
NET COMBINED SYSTEM COST	$18,200

*Costs are presented in 1980 dollars.

should the Purifax system be abandoned by mid-year 1980, the several year interim before co-incineration became a reality would be beyond the reasonable or permissible duration of the recommended interim sludge handling program of raw sludge injection. In light of the recent Notice of Violation and Order to Take Corrective Action, a definitive decision regarding the future status of the Purifax system is imminent within months.

However, as shown in Table 11, the co-disposal of municipal refuse and wastewater sludge is approaching a break-even point with the proposed anaerobic digestion/sludge injection alternative from an economic standpoint. Recognizing the energy related aspects of the co-incineration alternative and the rapid recent rate of inflation of energy costs, it is advised that this option be seriously considered before making a definitive decision to implement any proposed alternate permanent plan.

5. Environmental Impacts of Plans Presented

The recommended interim and alternate permanent plans as well as Alternative No. 7, should it be further considered, can be anticipated to result in various unique insignificant environmental impacts. No significant adverse impacts are anticipated. The continuation of the existing sludge handling system is also associated with environmental impacts which have been thoroughly investigated as part of the Analytical Testing Program and are documented in Chapter II. The other plans presented vary in the nature and degree of their associated impacts; however, certain features are noteworthy. First and foremost, it is to be emphasized that wastewater treatment and in particular sludge stabilization and disposal are necessary activities that inevitably create and disseminate odors that contaminate the air and offend the olfactory sense of the average citizen. Such odors can be judiciously controlled, but their total elimination is economically prohibitive and in some cases not even possible. This fact is especially relevant to the Helena situation where offensive odors have been a primary concern. The local citizenry should not delude themselves by believing that activities at their wastewater treatment facility will be odor-free, whether the existing Purifax system continues to operate or is replaced.

It is also significant that any sludge disposal plan which uses the soil as an ultimate repository for stabilized sludge risks the possibility of contamination, however slight, of underlying groundwater. Obviously, judicious planning and operation of such programs is the key to minimizing contamination hazards and it is reasonable to expect that such activities can be carried out in a safe and innocuous manner. Because sludge represents a concentrated residue from diverse municipal wastes, certain undesirable materials such as heavy metals will impose a foreign load on any land disposal site, and such substances will be introduced in quantities in excess of ambient levels. Again, judicious safeguards are necessary to insure against significant environmental degradation.

a. Recommended Interim Plan

It is expected that the Recommended Interim Plan would only be operational for a short time period. The following impacts could be anticipated in conjunction with the interim sludge management measures proposal:

i. Judicious site selection for the raw sludge injection proposed and adequate runoff control measures will prevent serious contamination hazards to existing surface water resources. By injecting sludge to a depth of approximately one foot, earth cover will be effectively provided and the sludge will be retained by and stabilized within the soil. The concentrations of heavy metals reported in the Analytical Testing Program will remain unchanged. The potential for hazardous leachate formation and migration to underlying groundwater will be minimal due to the elimination of direct contact between the sludge and precipitation water, and the use of controlled application rates based on metal concentrations. The distance involved from the injection depth to the ambient groundwater table (12+ feet, typically) and the low sludge application rates proposed further safeguard against groundwater contamination. During winter operations the proposed low-level surface spray application of sludge would pose no direct threat to groundwater resources since the presence of a frost barrier would eliminate leaching problems. The surface water contamination risk would correspondingly increase, but would be minimized by use of selected minimal grade plots well removed from surface watercourses, by the presence of adequate remaining vegetative cover, by adequate runoff and erosion control measures, and by the incorporation into the soil provided by subsequent injection over the site immediately in the spring.

The activated carbon application proposed as a contingency measure would have no deleterious impacts to surface or groundwater resources; the net effect would actually be beneficial since suspect organic compounds would be removed from a liquid phase and permanently bound into the carbon solids.

ii. Air quality impacts anticipated in conjunction with the proposed interim plan would primary involve odor generation. As previously discussed, sludge disposal cannot be accomplished without some risk of offensive odors. The injection of raw sludge into the soil during frost-free months would result in no odor release other than minimal occurences associated with pumping, handling or possible accidental spills. Winter operations proposed would be riskier from an odor standpoint, despite the inherent odor abatement associated with cold weather. Low-level surface spray application would undoubtedly result in some odor release, and a remote site would necessarily be required. The periodic midwinter thaws typical in the Helena Valley would afford the time of greatest odor hazard. The actual intensity and offence of the odors associated with winter spraying would not be precisely determined until the process was actually implemented on a trial basis. However, it is anticipated that nothing of the magnitude of the current odor problem would be experienced.

An impact to air quality from the distribution of airborne pathogens is not expected; direct injection of sludge will provide a suitable earth cover. During winter months, if low-level spraying is to be utilized, the combination of adherence to vegetative material, the instantaneous freezing induced by low temperatures, and the use of a remote, access-controlled site will provide adequate safeguards. The alternate of winter lagoon storage would afford no risks above those already existing at the treatment facility.

iii. A minor impact to future land uses of the sites utilized for raw sludge injection will result. As discussed previously, certain restrictions are legally required at the site(s) to assure protection of food chain products and public health. If City-owned ground is to be used, problems will be minimal; the use of other sites will require coordination and cooperation with the respective land owners involved. Some land would necessarily be temporarily removed from production of consumable grains and the grazing of livestock.

iv. No impacts to community facilities or cultural resources are associated with the proposed interim plan.

v. The economic impact of the interim plan would be significant to the City. The recent Order of Compliance requires that such measures be adopted, and the capital requirements are very significant. It will be necessary that the City obtain additional revenue-generating capabilities through whatever means are available to meet these requirements.

b. Recommended Alternate Permanent Plan

The following insignificant environmental impacts are anticipated as a direct result of implementation of the Recommended Alternate Permanent Plan.

i. Impacts to surface and groundwater resources are anticipated to be similar to, although to a lesser degree, those presented for the interim plan. Without any enforced reduction in the amounts of heavy metals reaching the municipal sewer system, the metals content of the sludge will continue unchanged. Anaerobic digestion will not have any reducing effect on these concentrations. Digestion will have the effect of reducing the levels of certain organics in the sludge through biological processes; however, other organics associated with bacterial metabolism will increase in concentration. The chlorinated organics suspected to form in the existing Purifax process will be removed. Controlled land application rates for sludge disposal will afford protection against contamination hazards from metals and other deleterious substances. The large areas involved in a land application system insure that no isolated area receives a sufficient amount of sludge to afford significant opportunity for harmful leachates to occur. This is considered superior to the existing sludge landfill site where the waste is concentrated for disposal. Further assurances against environmental degradation are afforded by

the soil characteristics in the areas considered for land application; relatively high pH and soil cation exchange capacity will promote ready assimilation by the soil of metals present in the sludge.

The environmental compatibility of surface spray application during the winter months would depend on judicious application and site preparation to prevent runoff contamination of surface waters. The presence of suitable vegetative cover and the incorporation of the sludge into the soil the following spring would again be critical.

ii. Air quality would be safeguarded under the Recommended Alternate Permanent Plan. The sludge stabilization afforded by anaerobic digestion would eliminate virulent pathogens completely. The opportunity for odor dissemination is also greatly reduced by the stabilization process. The soil cover afforded in the injection process should prevent odor release during summer operation. During the winter, the opportunity for odors could persist whether the sludge is surface applied or stockpiled in the existing lagoon system. Thaw periods will be the most troublesome. The use of a relatively remote spray application site will be the best assurance against any odor offense. If the lagoon storage option is used, experience will dictate whether lagoon covers are necessary.

iii. Future land uses of the injection sites utilized will result in and will primarily involve temporary crop farming and livestock grazing restrictions. These restrictions are compatible with the projected land uses of all sites under consideration, and no long-term limitations are imposed should unforeseen changes in the land use occur. Site II would potentially be the most severely impacted of the three sites since it is exclusively in private agricultural use at present. However, the land owner has indicated a strong interest in negotiating for the use of portions of his property for sludge disposal.

iv. No impacts to cultural resources of the area are associated with the Recommended Alternate Permanent Plan. Community facilities which include the Helena Wastewater Treatment Plant would necessarily be expanded by the addition of a new anaerobic digester, related equipment, and the negotiated lease of appropriate additional land for sludge application.

v. The economic impact of the Alternate Permanent Plan would require that the City raise significant additional capital for the construction of new facilities. This would require substantial additional revenue, and would probably result in an increase in the sewer rates assessed to the local citizens. Such rate increases would be obtainable only with Public Services Commission approval.

c. Alternative No. 7 - Municipal Solid Waste/Wastewater Sludge Co-Incineration

The anticipated environmental impacts associated with the co-incineration alternative differ substantially from those of the Interim and Alternate Permanent Plans summarized above. This

is due to the unique processes included in this alternative. The projected impacts can be summarized as follows:

i. Few opportunities for an impact to water resources in the Helena Valley exist with this alternative. The dewatering of the raw sludge on belt press equipment will create a liquid sidestream of high organic content that will be recycled to the existing liquid treatment process at the treatment plant. Thus the sidestream will be adequately treated through the plant, and the quality of the plant effluent will remain unchanged. The modular incinerators proposed at the Fort Harrison facility use a limited amount of water for quenching of the resultant ash. This would generate a small, periodic discharge to the existing wastewater treatment lagoons at the hospital site. The quantity and quality of this wastewater discharge would remain essentially unchanged by the introduction of sludge to the incineration process.

Ash from the incineration process would be disposed of at a Class III landfill site in the vicinity. The sludge ash would be only a minor and comparatively innocuous addition to the total disposal volume due to the thoroughness of sludge combustion.

ii. Air quality considerations for this alternative pose no significant problems. The dewatering and transportation of raw sludge could result in minimal isolated odors, but the location of dewatering equipment within the existing Sludge Oxidation Building and the use of a covered trailer for transportation would eliminate the opportunity for public offense.

Particulate and gas emissions at the Co-Incineration Facility would remain essentially unchanged by introduction of dried sludge to the incinerator feed. The proposed modular incinerators utilize a reburning process to eliminate noxious emissions in their waste gas stream, and the technique has proven to be very successful. Periodic release of waste steam would be accomplished to the atmosphere at the facility, but would again remain unchanged by the inclusion of sludge in the process. Off gases from the rotary sludge drier would be routed through the incinerators to assure cleansing before discharge to the atmosphere.

iii. Land use impacts anticipated with the implementation of a co-incineration process would be minimal. No additional land in the vicinity of either the Wastewater Treatment Plant or the Co-Incineration Facility would be affected by the sludge incineration process.

iv. No impact is anticipated to cultural resources of the area due to this program. The Fort Harrison Co-Incineration Facility would be owned and operated by the Veterans' Administration, and thus would become a public federal facility.

v. The economic impact of this alternative would again require significant capital expenditures by the City in conjunction with the Veterans' Administration Hospital. The exact allocation of cost burdens would need to be negotiated. Costs to the City would necessarily involve generation of additional revenue, with a probable increase in sewer rates, at least temporarily. If this alternative were to be implemented, inflating energy costs could substantially increase the facility's own revenue in the future, and result in an eventual reduction in local sewer rates.

APPENDIX 1

List of Abbreviations

APPENDIX 1

LIST OF ABBREVIATIONS

COD	carbonaceous oxygen demand, a measure of oxidizable material present in a sample
ac	acre
cfs	cubic feet per second
fps	feet per second
gal	gallon
gpcd	gallons per capita per day
gpd/sf	gallons per day per square foot
gpd	gallons per day
gpm	gallons per minute
hp	horsepower
lb/day	pounds per day
mgd	million gallons per day
mg/l	milligrams per liter
pH	hydrogen ion concentration
ppm	parts per million
psi	pounds per square inch
PVC	polyvinyl chloride
scfm	standard cubic feet per minute (at 68 ^{o} F and 14.7 psia)
SWD	sidewater depth
ug/l	micrograms per liter

APPENDIX 2

Description of Analytical Testing Program
and
Results of General Chemical Analyses

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November 19, 1979

MEMORANDUM

Re: Analytical Testing Program for Helena Sludge Handling Study

A comprehensive chemical testing program has been implemented as part of the Helena wastewater sludge handling study to evaluate the existing sludge oxidation facility as well as other alternative technologies under consideration. This is a broadly-based program oriented not only toward investigation of associated noxious odors produced, but also toward the environmental ramifications associated with the various processes.

Various sludge land application systems have been suggested as a sequel or an alternative to the present system. Consequently, analyses are being performed for compounds in both raw and oxidized sludge samples as well as the contributing wastewater streams that would affect the practicality of such land application. The presence of heavy metals, various nitrogen forms, and assorted anions (chloride, sulphate, phosphate) control the amount of sludge that can be land applied in an environmentally sound manner. The chlorine oxidation of municipal sludge may have a potential for excessive dissolution of certain anions and heavy metals, and analyses performed on both raw and oxidized sludge samples should demonstrate the extent of such occurrences.

A significant potential benefit of land application of wastewater sludge is the organic fertilizer/soil conditioner benefit accrued by the soil thus treated. Parameters such as sludge carbon content (COD, TOC), phosphate content and trace nutrient value dictate the agricultural benefit to be anticipated from the sludge. Other characteristics of municipal sludge such as pH, anion content and heavy metal content can be of adverse effect and should be verified to be within acceptable limits.

Anaerobic sludge digestion is also being considered as an alternative sludge handling system to chlorine oxidation. As a process, it is dependent upon similar nutrient and carbon contents and is somewhat sensitive to the presence of certain deleterious substances such as heavy metals. Thus, analyses performed will also enable evaluation of this treatment alternative.

Additional heavy metals analyses are being performed on wastewater composite samples taken from the three major trunk sewers lines serving the Helena area to ascertain the source(s) of heavy metals, if they are demonstrated to occur in the sludge. Excessive heavy metals in many cases tend to demonstrate the presence of inadequately pre-treated industrial waste discharges, and such strategic testing locations would enable future investigation to pinpoint problems if they are evidenced.

The concern over noxious odors associated with the present sludge oxidation system justified the implementation of a highly specialized testing program for organic compounds utilizing

gas chromatography/mass spectroscopy (GC/MS), a specialized analytical tool for such determinations. The rapid and widespread diffusion of odor from the chlorinated sludge lagoons indicates the presence of a relatively volatile compound(s) of an organic nature. For this reason, a GC/MS an-analysis for volatile organics in the chlorinated sludge has been initiated to specifically address the odor problem. Identification of the volatile organic constituents of the treated sludge, while not guaranteeing positive identification of the odor-causing compound(s), will possibly provide this, and at least will permit better understanding of the odor-producing mechanism. Contingent on evaluation of the results of this analysis, further volatile organics testing of additional samples, such as the raw sludge, could be instituted to investigate any change in volatile organic compounds induced by sludge chlorination.

An additional analytical opportunity afforded by GC/MS technology is a comprehensive screening for a broad class of organic compounds designated by the E.P.A. as priority pollutants due to their hazardous potential. Certain priority pollutants are volatile organic compounds and will be detected by the volatile organics test. Thus the results of the volatile organics analysis will give a strong indication as to whether priority pollutants testing would be warranted. The demonstrated presence of such compounds would be of crucial significance in assessing the environmental soundness of any contemplated sludge disposal system.

A primary concern regarding the current sludge handling system utilizing lagoon storage and drying of the chlorinated sludge is the possibility afforded for contamination of groundwater with any deleterious substance present. A unique opportunity for investigation of this possibility was afforded by the installation of a PVC underdrain system in the sand bed of a filled lagoon. Due to the relatively inert nature of the sand fill, the effluent from the underdrain piping is representative of the lagoon leachate that must pass through the soil strata to reach the groundwater. Analyses performed on samples of the underdrain water will be evaluated in conjunction with the assimilation capability of the underlying soil to determine the potential for contamination that might exist. Such analyses tentatively exclude provisions for GC/MS scans for volatile organics and priority pollutants in the underdrain water, but could be modified to include these parameters should other GC/MS test results demonstrate justification.

The aforementioned testing program is outlined on the two following attachments.*Attachment I summarizes the different tests performed on the various samples as well as the respective testing agencies involved. Most analyses were done locally, with the exception of those requiring GC/MS capabilities. These are being done by Lauck's Testing Laboratories, Inc., of Seattle. Mike Nelson, Chief Chemist for Lauck's, visited the Helena Wastewater Treatment Plant on Wednesday afternoon, November 14, 1979, to facilitate implementation of the GC/MS testing program. He discussed the laboratory's capabilities for this type of testing, which were in complete accordance with

*Attachments not included in this report.

the present needs. The cost of the volatile organics analysis of a sample of the chlorinated sludge is estimated at $200 to $300, including sample containers, sample preparation and analysis. Additional samples submitted for the same analysis would be similarly priced. The cost for the additional comprehensive priority pollutants analysis would be approximately $1,600, and would not be implemented without strong justification. A logical progression for GC/MS testing is presented in Attachment II and could proceed as far as positive indications and fiscal considerations warranted.

Heavy metals analyses for eight common elements are being performed by the Montana Department of Health Laboratory at a cost of approximately $55 per sample. Six samples are presently being analyzed. Additional analyses are being performed by Helena Wastewater Treatment Plant personnel.

In addition to these analytical testing programs, an extensive literature search is being conducted regarding both sludge oxidation and alternative technologies as well as problems inherent in each. Contacts are continuing with manufacturers and designers of the present sludge handling system as well as state and federal regulatory agencies. The E.P.A. is currently proceeding with two high-priority studies of the chlorination of municipal wastewater sludges, and will be focusing particularly on associated environmental hazards. Documented results of these studies will not be available by mid 1980. In the interim, the localized testing program outlined herein will provide reliable data site-specific for the Helena facility. Thus objective recommendations can be made for the continued operation, modification or replacement of the current sludge handling system on the basis of the results of this testing program.

Alden Beard

APPENDIX 2

COMPILED ANALYTICAL TEST RESULTS
HELENA SLUDGE HANDLING SYSTEM
(All results in mg/l unless otherwise specified)

Parameter	Helena Sewer West	Helena Sewer Central	Helena Sewer East	Raw Sludge	Freshly Purifaxed Sludge	Lagoon Under-drain	Lagoon Super-natent	Comments
Heavy Metals								
Cadmium total	<0.005	<0.005	<0.005	0.42	0.34	0.29	0.11[a] 0.14[b]	
Copper total	0.28	0.18	0.40	47.90	38.90	19.50	6.7[a] 13.0[b]	
Manganese total	0.04	0.04	0.05	3.00	2.36	15.30	1.2[a] 2.1[b]	
Lead total	<0.05	<0.05	0.20	6.72	6.03	0.12	0.73[a] 0.77[b]	
Chromium total	<0.05	<0.05	<0.05	1.00	0.88	<0.03		
Mercury total	<0.0004	<0.0004	<0.0004	0.095	0.075	<0.001		
Nickel total	<0.10	<0.10	<0.10	0.49	0.40	0.38		
Zinc total	0.25	0.20	0.79	57.80	46.8	35.80	19.0[a] 26.0[b]	
Anions								
Chloride							1310.0[a] 1260.0[b]	
Sulfate							450.0[a] 98.7[b]	
Nitrogen								
$NO_2 + NO_3$–N				0.02	0.38		0.34	
ammonia--N				450.0	340.0		330.0	
TKN				130.0	1700.0		450.0	
Miscellaneous								
pH				5.1	2.1	3.1	2.5	Units = pH Units
COD, total				3660.0				

APPENDIX 2

(CONT.)

COMPILED ANALYTICAL TEST RESULTS
HELENA SLUDGE HANDLING SYSTEM

(All results in mg/l unless otherwise specified)

Parameter	Helena Sewer West	Helena Sewer Central	Helena Sewer East	Raw Sludge	Freshly Purifaxed Sludge	Lagoon Under-drain	Lagoon Super-natent	Comments
Volatile organics					c			Reported elsewhere by Lauck's lab (Appendix 3)
Free Cl residual							c	Reported elsewhere on combined lagoon supernatent & solids (Appendix 4)

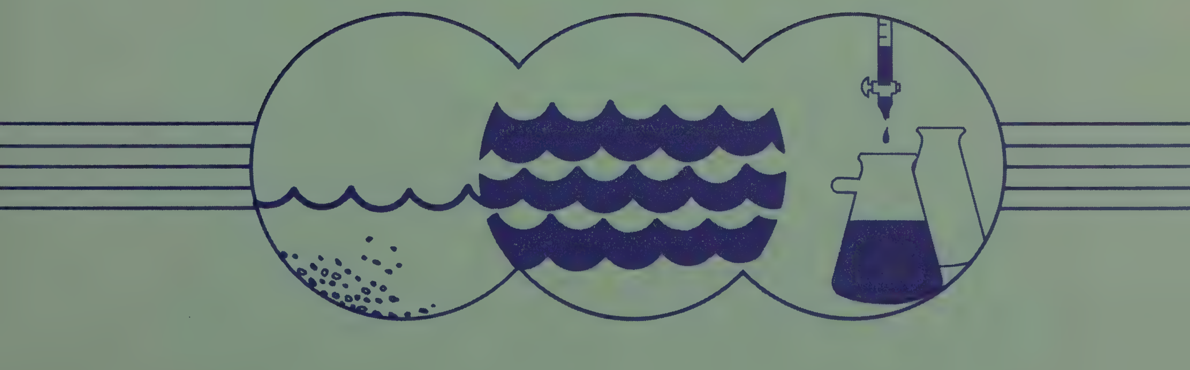
[a] Reported earlier by State Lab for MDHES Water Quality Bureau, September 22, 1978.

[b] Reported earlier by State Lab for MDHES Water Quality Bureau, June 18, 1979.

[c] Analysis reported elsewhere (see following appendices).

APPENDIX 3

Results of Volatile Organics Analysis



APPENDIX 3

VOLATILE ORGANICS ANALYSIS OF FRESHLY PURIFAXED SLUDGE

Sampling Date: December 21, 1979
Analysis Performed By: Lauck's Laboratory, Seattle, Washington
Analytical Technique: Helium purge and trap technique followed by gas chromatography/mass spectroscopy with computerized library search identification.

RESULTS

Compound	Estimated Concentration (ug/L)
1, 1-dibromo-2-chloro-2-fluoro-cyclopropane	40
chloromethane*	10
chloroethane*	<10
dichloromethane*	20
methyl oxirane	100
1-chloropropane	< 10
trichloromethane (chloroform) †	20
1, 1, 1-trichloroethane*	10
tetrachloromethane † (carbon tetrachloride)	10
trichloroethane*	<10
3-methyl-2-butanone	<10
1, 3, 5-cycloheptatriene	40
ethyl benzene †	<10
5-methyl-2-hexanone	<10

Compounds identified with a lower probability by a computerized library search:

dichlorodifluoromethane*	<10
ethanol	<10
1-propanol	<10
3-methylpropane	<10
3, 3-dimethyloxetane	<10
3-methylbutane	<10
3-methylhexane	<10

* Compounds included on the EPA priority pollutants list (ref. P.L. 92-500 Federal Clean Water Act, and paragraph 11 of the Consent Decree in "Natural Resources Defense Council, et.al, vs. Train" 8 ERC 2120 (D.D.C. 1976))

† Compounds cited as suspected carcinogens to laboratory test animals as per EPA tentative water quality published for appraisal and comment (ref. Federal Register 44:52 and 44:144)

APPENDIX 4

Results of Lagoon Stage and Free Chlorine Residual Monitoring

APPENDIX 4

CHLORINE RESIDUAL AND LAGOON STAGE DATA (WEST CENTRAL LAGOON CELL)

Date	Free Chlorine Residual (mg/l)*	Lagoon Stage†
11/08/79	(flow to lagoon ceased at end of day; no further addition planned)	
11/09/79	312	12′ 5¼″
11/12/79	251	12′ 6″
11/15/79	198	12′ 6¾″
11/18/79	(first ice on lagoon, complete skim)	12′ 7¼″
11/20/79 (½″ ice)	126	12′ 7¾″
11/30/79	22	12′ 8″
12/10/79 (1″ ice)	8.9	12′ 8½″
12/18/79	–	12′ 9″
01/08/80	–	12′ 10¼″
01/18/80 (5″ ice)	3.1	12′ 10½″

*Samples for analysis always obtained at a point approximately 50 ft. straight off discharge pipe; lateral center of lagoon.

† Measurements do not reflect total lagoon stage; a metal rule was affixed to a stage stake and numbers are arbitrary, but comparatively accurate. Beginning stage was approximately 30 inches total water depth (taken to top of sediment).

APPENDIX 5

Results of Activated Carbon Batch Tests

APPENDIX 5

RESULTS OF ACTIVATED CARBON BATCH TESTS FOR ODOR CONTROL IN PURIFAXED SLUDGE

Date: January 21, 1980

Location: Helena Wastewater Treatment Plant Lab Facility

Tests Performed By: Alden G. Beard

All tests performed on freshly Purifaxed sludge collected and left in sealed containers for one hour +. Sludge collected: 10:45 a.m. Tests begun 11:45 a.m.

All tests run as follows:

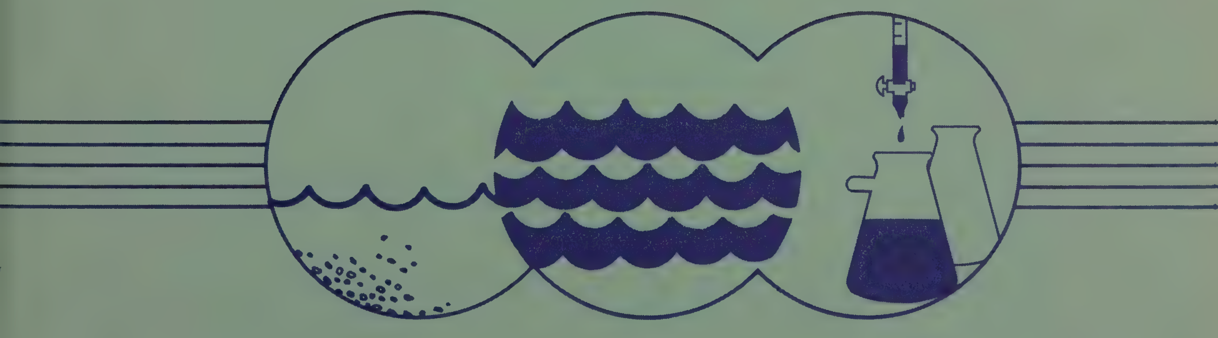
1. Powdered activated carbon dosages weighed on analytical balance and batched dry into 500 ml glass beakers.
2. 500 ml of thoroughly mixed Purifaxed sludge added to beakers individually.
3. Magnetic stirring to simulate flash mix performed for a period of five minutes.
4. Beakers covered with airtight Para-film and set aside for one-half hour +.
5. Five individuals lifted covers on beakers one at a time and sniffed contents; their comments were recorded based on the following parameters:
   - Do you detect any odor?
   - How would you describe the odor?
   - Is the odor a definite Purifax-type odor?
   - Is the odor offensive?
6. A blank was also batched, mixed and set aside for comparison using only Purifaxed sludge with no activated carbon addition.

RESULTS

Sample No.	A/C Dose	Wt. of A/C	Panelist 1	Panelist 2	Panelist 3	Panelist 4	Panelist 5
1	10 mg/l	5 mg	Same as blank, no odor change	Same as blank	Less odor than blank	Same as blank	Bad, very sour odor
2	100 mg/l	50 mg	Same as blank, no odor change	Same as blank	Less odor yet than blank	Same as blank	Same odor as blank, strong chlorine and vomit-like smell
3	1 g/l	500 mg	Slightly less odor than blank, definitely a Purifax odor	A little change from blank	Even less odor yet than Sample 2	Definite chlorine odor	Bad, chlorine odor and vomit-like smell
4	10 g/l	5 g	Significantly less odor, faint, suggestive of chlorine, not really a Purifax odor	A great change, faint chlorine odor	Just a bit of Purifax odor	Trace of odor, slightly objectionable, sour	Chlorine odor
5	40 g/l	20 g	No odor	No odor	No odor	No odor	A little bit of a sour odor.
6	100 g/l	50 g	No odor	No odor	No odor	No odor	No odor
7	200 g/l	100 g	(This volume os A/C would not go into solution with the sludge sample; sample scrapped)				

APPENDIX 6

MDHES Notice of Violation and Order to Take Corrective Action



Department of Health and Environmental Sciences
STATE OF MONTANA HELENA, MONTANA 59601

A.C. Knight, M.D.,
DIRECTOR

December 28, 1979

Mayor Kathleen Ramey
City-County Building
316 North Park
Helena, Montana 59601

RECEIVED
JAN 4 1980
PUBLIC UTILITIES

Re: Notice of Violation and Order to Take Corrective Action--Helena Sewage Treatment Plant

Dear Mayor Ramey:

Attached is a Notice of Violation and Order to Take Corrective Action concerning the Helena sewage treatment plant. We recognize that the City of Helena has spent considerable money and effort to correct the odor problem at the sewage treatment plant and the steps taken will probably lessen the problem. However, we still believe that, as it is currently operated, the plant will continue to be a public nuisance, especially during warm weather. The City must be prepared with a contingency plan to cure the nuisance unless it can show, through its studies, that the problem can be corrected through the changes already made and which can be made during the next few months.

If you have any question concerning this matter, please contact Mr. Don Willems, Administrator, Environmental Sciences Division, at 449-3946.

Sincerely,

AC Knight

A.C. Knight, M.D., F.C.C.P.
Director
Department of Health and Environmental Sciences

Enclosure
cc: David Ashley, City Manager

BEFORE THE MONTANA DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES

In the matter of the sewage treatment) facility of the City of Helena,) Montana)	NOTICE OF VIOLATION AND ORDER TO TAKE CORRECTIVE ACTION

To: The Mayor, City Commissioners, and the City Manager of Helena, Montana

NOTICE OF VIOLATION

You are hereby given notice by the Montana Department of Health and Environmental Sciences ("DHES") that you are in violation of rule 16-2.14(1)-S1480(1) of the Administrative Rules of Montana, governing control of odors. The violation is as follows:

1. The City of Helena, as part of its operation, operates a sludge treatment facility at its sewage treatment plant located north of Helena, Montana.

2. ARM 16-2.14(1)-S1480, Odors, Control of, prohibits the emission of odors in such manner as to create a public nuisance.

3. During the months of April through November, 1979, the DHES received numerous complaints concerning noxious odors emitted from the sludge treatment facility from members of the public living or working near or passing by the sewage treatment plant.

4. The foregoing complaints establish that odors have been and continue to be emitted from the sludge treatment facility in such a manner as to create a public nuisance, and thereby constitute a violation of ARM 16-2.14(1)-S1480(1).

ORDER TO TAKE CORRECTIVE ACTION

Based on the foregoing Notice of Violation, and pursuant to the enforcement authority granted to the DHES by Section 75-2-401, MCA, it is hereby ordered that the City of Helena immediately take action adequate to eliminate the nuisance referred to above, and, more specifically, shall:

1. Proceed as rapidly as possible with completion of the current engineering evaluation of the sludge treatment portion of the Helena sewage treatment plant in order to determine if it can reasonably be operated and/or altered so that it will function in compliance with ARM 16-2.14(1)-S1480, the rule governing

control of odors. A report of the findings of this evaluation shall be submitted to DHES no later than February 15, 1980.

2. If the engineering evaluation shows the facility as designed can be made to comply with the standards of the odor rule cited above, include in the report required by paragraph 1 above a date when operational or other changes necessary to bring the facility into compliance will be completed.

3. If the engineering evaluation determines that the sludge treatment facility as designed cannot be expected to comply with the above-cited odor rule, provide to DHES by March 1, 1980, a compliance schedule acceptable to DHES for abatement of the public nuisance described in the Notice of Violation. This schedule shall address both temporary and permanent measures to be taken by the City of Helena to abate the nuisance, and provide dates for submittal of plans, any necessary procurement of land, ordering and delivery of any necessary equipment, completion of installation of that equipment and any necessary related construction, and the date the sludge treatment facility will be in compliance with ARM 16-2.14(1)-S1480(1). The temporary measures must be fully implemented no later than May 1, 1980.

4. The dates required above to be submitted to DHES by the City of Helena are subject to the approval of DHES; once approved, they shall become part of this Order to Take Corrective Action, and failure to complete the actions described above by the respective dates agreed upon shall constitute a violation of this Order.

OPPORTUNITY FOR HEARING

Pursuant to Section 75-2-401, MCA, this Order becomes final unless, within thirty (30) days after the Notice and Order are received, you request in writing a hearing before the Board of Health and Environmental Sciences.

DATED this ____ day of December, 1979.

A C Knight

A.C. KNIGHT, M.D., Director
Department of Health and Environmental Sciences